Dealing with Uncertainty in Value Investing

Ioannis Chatzilakos

SCHOOL OF ECONOMICS, BUSINESS ADMINISTRATION & LEGAL STUDIES

A thesis submitted for the degree of

Master of Science (MSc) in Banking & Finance

January 2018

Thessaloniki – Greece

Student Name:	Ioannis Chatzilakos
SID:	110316003
Supervisor:	Prof. Panagiotis Artikis

I hereby declare that the work submitted is mine and that where I have made use of another's work, I have attributed the source(s) according to the Regulations set in the Student's Handbook.

January 2018

Thessaloniki - Greece

Abstract

This dissertation was written as part of the MSc in Banking & Finance at the International Hellenic University.

In this thesis we develop an analytical framework for dealing with uncertainty for the practitioners that follow the investing strategy called value investing. We derive a deterministic and a stochastic valuation formula that separate the different sources of value of a company. We also provide alternative methodologies to the common risk-adjusting approach in order to deal with valuation risk, as well as a quantitative approach to apply the principle of Margin of Safety. Last, we conducted a case study for the public company called "The Coca-Cola Company" to illustrate the application of the framework developed in the main body of the dissertation.

At this point, I would like to express my deepest appreciation for my supervisor, Professor Artikis, whose guidance and expertise have been proved valuable throughout the project. In addition, I would like to thank London Business School for providing me access to the database S&P Capital IQ and the software @Risk, without which this thesis wouldn't be possible.

Keywords: value investing; valuation; stochastic modelling; valuation risk

Ioannis Chatzilakos

30/01/2018

Contents

1. Introduction

Value investing is an investment strategy in which an investor invests in securities that trade at a significant discount to their intrinsic value. It was first pioneered by Benjamin Graham and David Dodd during the 1930's and has since found a lot of supporters around the globe, including some of the most successful investors that ever existed. In every value-oriented investment process, there are three fundamental steps:

[1] Identify possibly undervalued securities through a screening process.

[2] Calculation of the intrinsic value through a valuation process.

[3] Comparison of the intrinsic value with the current market price, and, if a significant discount exists, which is known as "Margin of Safety", then the investment is undertaken.

By examining this process, we identify that there is a lot of inherent uncertainty in the second and third step. Although a lot of literature has been written on this subject, we have found that most them are either qualitative in nature or fail to address simultaneously the uncertainty of both steps in a quantitative manner. Thus, the purpose of this dissertation is to create a unifying quantitative framework under which a value investor can model and measure the uncertainty inherent in the investment process.

In Chapter II of this thesis we conduct a review of the existing literature on the subjects under examination. In Chapter III, we analyse the existing valuation formulas and derive a new valuation formula under a deterministic framework that is based on Bruce Greenwald's work and does not exist in this form in any of the contemporary valuation textbooks. In addition, we transform the deterministic formula into a stochastic one by substituting the expected values of the parameters with random variables, thus creating a new stochastic valuation model. In Chapter IV, we deal with the uncertainty in steps two and three of the investment process. We discuss about issues of the current practice of risk-adjusting the discount rate to model for uncertainty and provide a number of alternative frameworks that can be selected by the investor according to their current circumstances. We also provide two methods for quantifying and applying the principle of "Margin of Safety". In Chapter V, we conduct a case study for the US Company "The Coca-Cola Company" and apply all the tools we developed in chapters III and IV. Last, in Chapter VI, we summarise the results and comment on the framework developed.

2. Literature Review

The main prism through which we analyse risk and uncertainty is the investment strategy called value investing, first conceptualized by Benjamin Graham and David Dodd (1934; Graham, 1949). Several other practitioners have written about this style of investing over the years, using the initial framework developed by Graham and Dodd while making their own adjustments, leading to variety of different styles that fall under the umbrella of value investing. Using Damodaran’s framework (2012) we can breakdown value investors in three main categories, namely:

- Passive Value Investors that use systematic methods like stock screens to identify firms with specific characteristics. Joel Greenblatt’s Magic Formula Investing (2005, 2016) is such an example.
- Contrarian Value Investors that seek for out-of-favour stocks, troubled or distressed companies and misunderstood industries that are in cyclical downturn. Seth Klarman (1991, 2009) is an advocate of this style.
- Activist Value Investors that build large positions in companies that are poorly managed and then try to push for changes. Hedge fund manager Bill Ackman is a well-known activist value investor.

Although the style is differentiated there are some principles that are shared among all practitioners, with “Margin of Safety” being evident in all those styles (Buffet, 1984; Athanassakos, 2012). Given that we provide a comprehensive framework that an investor can use to quantify this principle and tie it to valuation risk, we contribute in current value investing literature that includes not only the aforementioned sources, but also Greenwald (2001), Whitman et. al (2009), Browne (2006), Mclenann (2011) and Carlisle (2014).

Undoubtedly, the origins of contemporary valuation literature upon which we build in Chapter III were set by Modigliani & Miller in their famous articles about valuation and capital budgeting (1958, 1961, 1963). Using MM’s framework and other corporate finance practitioners’ frameworks, Koller et. al (2010) have developed one of the most comprehensive valuation frameworks, commonly known as “The McKinsey Valuation Framework”. Following similar steps, Professor Aswath Damodaran has created a similar valuation framework that he describes in his books (2010, 2012) and is also available through the Valuation course he teaches at Stern Business School. Both authors focus primarily in intrinsic valuations that take the form of a Discounted Cash

Flow analysis where risk is counted for by adjusting the discount rate, a method widely known as the WACC method that is taught in most business schools (see also Brealey, Myers & Allen, 2016).

Apart from the WACC method, two other methods are also popular that use the asset beta (pre-tax WACC) as the discount rate. The first one is the APV method first developed by Myers (1974) and is suggested for its superiority in valuing operating assets by leading corporate finance practitioners like Myers (1974), Brealy et. al (2016) and Luerhman (1997, 1997). The second is the Capital Cash Flows Method (CCF) developed by Ruback (2000). Last, the Economic-Value Added (EVA) method that was developed by Stewart (1991) is sometimes referred separately, but it uses the WACC as a discount rate and is more of a different measure for financial performance rather than a different valuation method.

Parallel with the deterministic valuation framework developed by Modigliani and Miller, leading authors in finance, engineering, and actuarial sciences focused in stochastic approaches to valuation and capital budgeting decisions. For the purposes of this dissertation, we will focus primarily in probabilistic approaches to the NPV investment rule as applied through a DCF analysis. These approaches are divided to the ones that have closed mathematical forms and the numerical ones. In both strands, the amount of cash flows, discount rate and the timing of cash flows can be considered as random variables.

Hillier (1963, 1969) was one of the pioneers of closed-form DCF analysis and provided a model to derive the distribution of the NPV of an investment, with the cash-flows considered as normally-distributed random variables. The main issue with closed-form probabilistic models is that they can only be derived for a limited types of cash flow distributions. In addition, correlations between all cash-flows need to be known. Hillier initially assumed that cash-flows are either independent or fully correlated. Wagle (1967), Canada et al. (1980) and Tufekci & Young (1987) derive formulas for the first two-moments and higher-moments of the stochastic NPV with stochastic cash-flows. They also provide a closed form of present worth for a probabilistic life span. In addition, Kim et al. (1999) provide methods to obtain the correlation coefficients for the cash-flows while empirical studies have also dealt with other correlation aspects (Johar et. al., 2010; Caramichael et. al. Hawas & Cifuentes, 2014). Other authors have tackled the issue of uncertain timing of cash flows (Young & Contreras, 1975).

Moving on to numerical approaches to valuation, Hertz (1964, 1968) was the first one to introduce simulations in valuation and suggested a method that has become known as the Monte Carlo method. Under this method, the independent random variables in a model are described by probability distributions and repeated random sampling from these distributions is used to obtain numerical results, as well as the distribution for the dependent random variable (usually the investment value). The main advantage of the numerical approach compared to closed form methods is that it isn't restrictive regarding the distributions for each independent variable, allowing the investor to apply this method in a variety of different investments. The advantages of this method are also discussed by Damodaran (2010, 2012, 2013), Casidy et. al (1970), Swirles & Lusztig (1968) and application is illustrated by Richardson & Mapp (1976), Hughes (1995) and Maged et. al (2010).

All the aforementioned methods would be categorized under the Income Approach in the International Valuation Standards Council IVS 105 Standard (IVSC, 2016). We also incorporate under our valuation model in Chapter III the cost approach as well, as described and applied by Klarman (1991), Greenwald (2001), Whitman et. al. (2009) and Carlisle (2014).

3. Valuation – Deterministic and Stochastic Models

3.1 Deterministic Valuation Model

How can an investor estimate with precision the intrinsic value of a security? The answer is simple: they can't. According to Damodaran (2010, 2012) and the International Valuation Standards Council (IVSC, 2016), the four approaches to valuation are:

[1] Intrinsic valuation (Income Approach), which relates the value of an asset to its intrinsic characteristics, i.e. its capacity to generate cash flows and the riskiness of those cash flows. It is usually done through a discounted cash flow method.

[2] Relative valuation (Market Approach), where the value of an asset is estimated by looking at the market price of comparable assets.

[3] Cost Approach, where the value of an asset is estimated either through the reproduction cost or, if undue time, risk and other factors are involved, through the liquidation value.

[4] Contingent claim valuation, where option pricing models are used to measure the value of an asset that has option characteristics.

The usual route that practitioners take is to calculate value under a deterministic framework using one or some of the aforementioned methods and then compare the valuations. Different methods of valuation require different assumptions, but, for the purposes of this dissertation, we will focus only on methods [1] and [3], i.e. intrinsic valuation and the cost approach.

The traditional DCF analysis in corporate finance can be summed up with the following equation:

$$\mathrm{V} = \sum_{\mathrm{t}=1}^{\infty} \frac{\mathrm{FCF_t}}{1 + \mathrm{WACC}^{\ \mathrm{t}}} \qquad (1)$$

The Weighted Average Cost of Capital in the theoretical world of Modigliani and Miller (MM) is the pre-tax cost of capital that the providers of capital to the firm require. If we incorporate taxes, then the WACC becomes the post-tax cost of capital to integrate the effects of the financing decisions to the value of the assets, mainly the tax-deductibility of interest payments.

In 1974, Myers proposed a different method that unbundles the effects of financing decisions, the APV method:

$$V = \sum_{t=1}^{\infty} \frac{FCF_t}{1 + r_U \ ^t} \quad + V \text{ financing effects} \qquad (2)$$

Since value investors typically deal with mature, constant-growing companies, we can use the simple case where the FCF is growing at a constant rate.

$$V = \frac{FCF_1}{r_U - g} + V \text{ financing effects } = \frac{FCF_0(1+g)}{r_U - g} + V \text{ financing effects} \qquad (3)$$

This FCF_0, also known as Adjusted Operating Earnings, is the current operating earnings that represent sustainable levels of distributable FCF in the long run. After doing some algebraic transformations, we end up with the following formula:

$$V = V\ L\ + V\ GCP\ + V\ EPP\ + V\ EPGP\ + V\ FE \qquad (4)$$

Where:

$$\begin{cases} V\ L\ = \text{Liquidation Value} = \text{Book Value} + \text{Liquidation Adjustments} \\ V\ GCP\ = \text{Going Concern Premium} = \text{Reproduction Adj.} - \text{Liquidation Adj.} \\ V\ EPP\ = \text{Earnings Power Premium} = \dfrac{FCF_0}{r_U} - \text{Reproduction Cost} \\ V\ EPGP\ = \text{Earnings Power Growth Premium} = \dfrac{FCF_0(1+g)}{r_U - g} - \dfrac{FCF_0}{r_U} \\ V\ FE\ = \text{Value from financing effects} = t_c D - \pi_B BC + \text{Agency Costs} \end{cases}$$

If the investor is also an activist investor and believes that they can implement changes that can enhance the value of the firm, then they can add an activist premium (AP) to their valuation. These changes could effectively lead to an increase $FCF_{0,}$ an increase in long-term growth g or other value-enhancing effects. Please note that in formula (4) FCF_0 is considered the sustainable long-term adjusted after-tax operating earnings as is currently, without any external effects. As such, our formula becomes:

$$V = V\ L\ + V\ GCP\ + V\ EPP\ + V\ EPGP\ + V\ FE\ + V\ AP \qquad (5)$$

The intuition behind this formulation is simple: Starting from liquidation value, each additional premium that an investor is willing to incorporate in his valuation process adds to valuation risk, i.e. the probability that his estimates are wrong. Obviously, even for liquidation value, there is uncertainty in our estimates that is inherited in every valuation process, but this uncertainty increases as we add parameters to the right-hand side of our equation. A diagram of the different sources of value and each premium for an imaginary firm can be seen below:

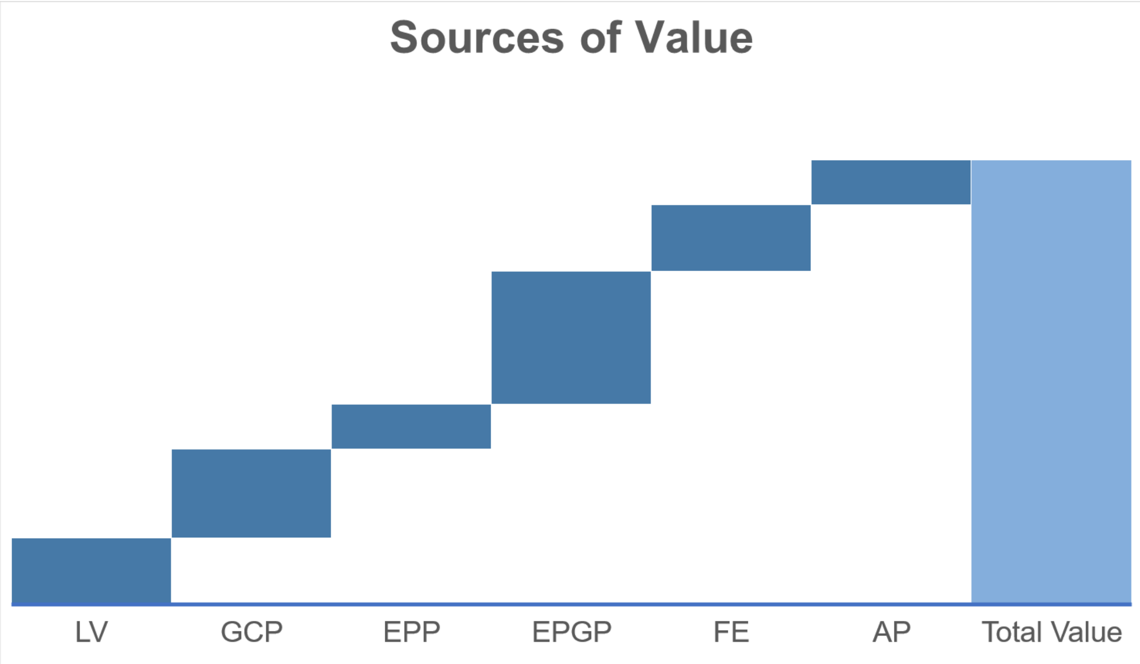

Figure 1: Sources of Value

Since every investor is free to select which premiums to include in their valuation, to make the formula more complete, we can multiply each source of value with an operator to include this ability. An ideal operator that fits our purposes is the Heaviside Step Function, which is formulized as:

$$H\ \ x\ \ := \frac{d}{dx}\max\{x,0\} \qquad (6)$$

An alternative and simpler form is:

$$H[x] = \begin{cases} 0, & n < 0 \\ 1, & n \geq 0 \end{cases} \qquad (7)$$

The graphical representation of the Heaviside Step Function is presented below:

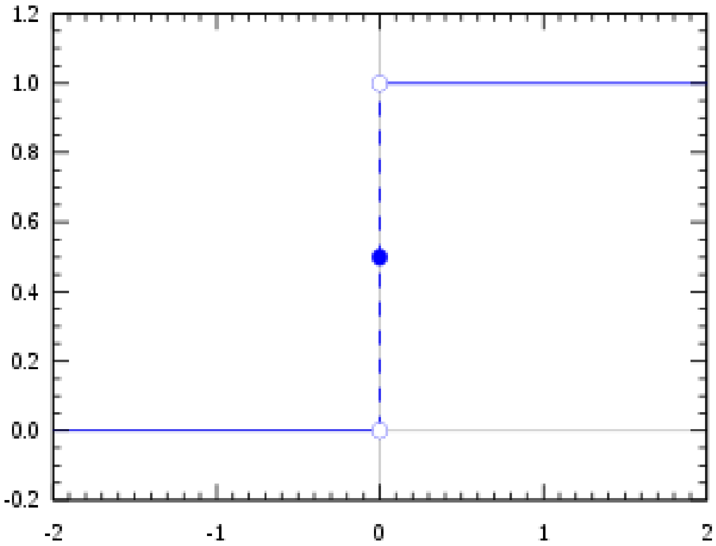

Figure 2: Heaviside Step Function for x=0
Source (https://goo.gl/NJ8XXH)

Therefore, the complete deterministic formulation of a company valuation is:

$$\mathrm{V} = \mathrm{H}[\mathrm{x}_1] \times \mathrm{V\ L} + \mathrm{H}[\mathrm{x}_2] \times \mathrm{V\ GCP} + \mathrm{H}[\mathrm{x}_3] \times \mathrm{V\ EPP} + \mathrm{H}[\mathrm{x}_4] \times \mathrm{V\ EPGP}$$
$$+ \mathrm{H}[\mathrm{x}_5] \times \mathrm{V\ FE} + \mathrm{H}[\mathrm{x}_6] \times \mathrm{V\ AP} \qquad (8)$$

This unifying valuation formula (8) can be applied by all different types of value investors, depending on their strategy and types of companies they analyse:

- *Distressed/Deep Value/Company in non-viable industry:* Focus solely on liquidation value and financing effects, i.e. $\begin{cases} x_1 = x_5 = 1 \\ x_2 = x_3 = x_4 = 0 \end{cases}$
- *Viable Industry but no competitive advantage:* Focus on reproduction cost and earnings power value without growth, i.e. $\begin{cases} x_1 = x_2 = x_3 = x_5 = 1 \\ x_4 = 0 \end{cases}$
- *Viable Industry and long-term sustainable competitive advantages:* Focus on earnings power value with growth, i.e. $x_1 = x_2 = x_3 = x_4 = x_5 = 1$.
- *Activist Investor:* For any of the three previous cases, if the investor can enhance the value of the firm through active involvement then $x_6 = 1$.

At this point, we would like to comment that the formula (8) allows an investor to incorporate other external factors that may affect the valuation of a company, primarily through the variable $\mathrm{V\ AP}$. That said, an investor should always be careful when they include $\mathrm{V\ AP}$ because it may lead to double counting.

3.2 Valuation under a stochastic framework

3.2.1 Measure Theory Primer

To transform the deterministic model of the formula (8) to a stochastic model, a distinguish needs to be made between the intuitive definition of a random variable and the axiomatic definition. The intuitive definition is that a random variable is “a variable that takes its values randomly”. In contrast, according to measure theory (Taylor & Karlin, 1998), the axiomatic definition of a random variable is:

Assume a measurable probability space (Ω, A, P), where Ω is a set, A is a σ-algebra and P is a probability measure on A. Then, a real-valued random variable is a function $X: \Omega \to \mathbb{R}$ such that $\{\omega \in \Omega: X(\omega) \leq x\} \in A \quad \forall x \in \mathbb{R}$. If we assume that the set $E \subset \mathbb{R}$, then the definition becomes $\{\omega \in \Omega: X(\omega) \in E\} \in A$. As such, we realise that random variables are functions, i.e. mappings from the sample space Ω to the set of real numbers:

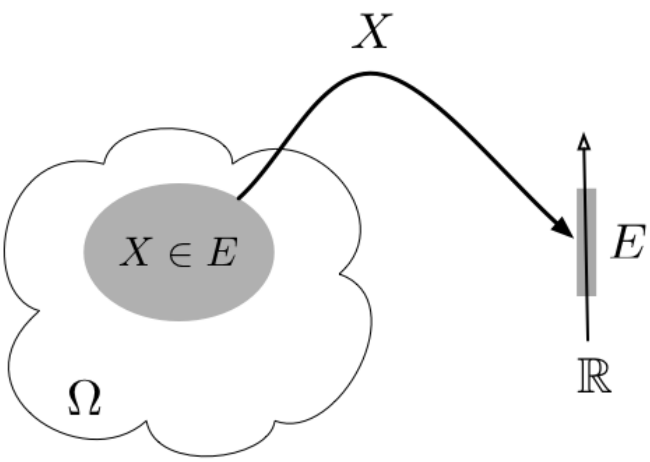

Figure 3: Random Variables as functions
(Source: http://theanalysisofdata.com/probability/2_1.html)

In addition, a probability measure P on (Ω, A) is a function $P: A \to [0,1]$ such that $P\ \emptyset\ = 0, P\ \Omega\ = 1$ and $P(\bigcup_{i=1}^{\infty} E_i) = \sum_{i=1}^{\infty} P(E_i)$. We also know that the distribution of a random variable is the probability measure P^X on $\mathbb{R}$ such that $P^X\ E\ = P(x \in E)\ \forall E \in B(\mathbb{R})$, where $B(\mathbb{R})$ is the Borel σ-algebra on $\mathbb{R}$. Last, the cumulative distribution function (cdf) of a random variable is the function $F: \mathbb{R} \to [0,1]$ such that $F(x) = P(X \leq x)$. Hence, we can see from the last two definitions that $P^X$is the probability measure induced on $\mathbb{R}$ by the cdf F. In fact, the distribution P^X of the random variable is a pushforward probability measure, i.e. we use the random variable X to “push forward” the probability measure P on (Ω, A) to the P^X on $\mathbb{R}$.

The last theorem of P^X as a pushforward measure allows us to discard the probability space Ω and work with probability distributions of X, effectively bridging the axiomatic definition with the intuitive one we are used to. Yet, although this transformation allows us to work with observable data, arbitrarily changing the probability distributions can be dangerous because it implies changes in the initial, unobservable probability space (Ω, A, P) as well.

3.2.2 Stochastic Valuation Model

The random variables that will be included in our stochastic model can be either discrete or continuous, depending on the situation. A random variable is discrete if the image of space Ω is countable while it is continuous if the image is uncountable, infinite or not. A discrete random variable has discrete probability distribution and is sufficiently described for our purposes by a probability mass function (pmf). In contrast, a continuous random variable has a continuous probability distribution and is sufficiently described by a probability density function (pdf). By the definition in our previous chapter, both types of random variables have defined cdfs and well-known transformations exist to induce the pmf or pdf from cdf.

Based on the variables of the equation (8), we will assume that Book Value is not a random variable and can be extracted directly from the balance sheet. In addition, the values of the step function are determined arbitrarily by the investor depending on their circumstances. Hence, the following variables will be considered stochastic, and will be denoted in italics:

$$
\begin{cases}
\text{Liquidation Adjustments} \rightarrow \widetilde{LVA} \\
\text{Reproduction Cost Adjustments} \rightarrow \widetilde{RCA} \\
\text{Adjusted Operating Earnings} \rightarrow \widetilde{FCF_0} \\
\text{Sustainable Long} - \text{term Growth} \rightarrow G \\
\text{Discount Rate} \rightarrow \widetilde{R} \\
\text{Tax rate} \rightarrow T \\
\text{Debt Value} \rightarrow \widetilde{D} \\
\text{Probability of Bankruptcy} \rightarrow \widetilde{\Pi_B} \\
\text{Bankruptcy Costs} \rightarrow \widetilde{BC} \\
\text{Agency Costs} \rightarrow \widetilde{AC} \\
\text{Activist Effect} \rightarrow \widetilde{V\ A}
\end{cases}
$$

Thus, our stochastic model becomes:

$$V = \mathrm{H}[\mathrm{x}_1] \times V\ \mathrm{L}\ + \mathrm{H}[\mathrm{x}_2] \times V\ \mathrm{GCP}\ + \mathrm{H}[\mathrm{x}_3] \times V\ \mathrm{EPP}\ + \mathrm{H}[\mathrm{x}_4] \times V\ \mathrm{EPGP}$$
$$+ \mathrm{H}[\mathrm{x}_5] \times V\ \mathrm{FE}\ + \mathrm{H}[\mathrm{x}_6] \times V\ \mathrm{AP} \qquad (9)$$

If V or any of the other random variables is a discrete random variable, then the moments of its probability distribution are given by:

$$\mathrm{E}\left[V^m\right] = \sum_{\mathrm{i}} \mathrm{x}_{\mathrm{i}}^{\mathrm{m}} \mathrm{Pr}\{V = \mathrm{x}\} \qquad (10)$$

If V or any of the other random variables is a discrete random variable, then its moments are given by

$$\mathrm{E}\left[V^m\right] = \int_{-\infty}^{+\infty} x^n dF(x) \qquad (11)$$

The equations (10) and (11) will become handy in the next chapter where we deal with risk, especially to calculate the first moment (mean), second (variance), third-normalized (skewness) and fourth-normalized (kurtosis) of the probability distributions.

4. Dealing With Risk

In our stochastic valuation model (9), the first moment (mean) $E[V]$ is the expected value of the asset under consideration and is equal to the value of V in the deterministic model (8). However, as this value ($E[V]$ or V) is uncertain, a risk-averse investor with an increasing and concave utility function assigns lower values to riskier assets. To incorporate this risk-aversion, we need to risk-adjust the calculated values $E[V]$ or V. This adjustment can be made either within the model, or by adjusting the value after the calculations are done.

4.1 Income Based Approaches

For the income-based approaches, the random variables are $\widetilde{FCF}_0, G$ and $\widetilde{R}$. To incorporate the uncertainty that is inherent in estimating the first-two variables, there are two distinct methods:

- Risk-adjusted Discount Rate method (RADR): This is by far the commonest method that is used where $\widetilde{R} = risk - free\ rate + risk\ premium$, with the risk-free rate a proxy for the time value of money and the risk premium corresponding to the riskiness of $\widetilde{FCF}_0$ and G. Depending on the model (APV vs WACC vs CFF), the risk-adjusted discount rate is either the pre- or post-tax cost of capital.
- Certainty Equivalent method: Use the risk-free rate as $\widetilde{R}$ to incorporate the time value of money and apply a certainty equivalent coefficient, either directly to $\widetilde{FCF}_0$ and G or to V to risk-adjust the value.

From the two available methods, the first-one is covered extensively in modern finance literature. Yet, many authors like Robichek & Myers (1966), Lewellen (1977), Haley (1984) and Schwab (1978) have identified conceptual problems with the use of the RADR method. In addition, it is common practice to use CAPM in the RADR method, a model that is discarded by many value investing practitioners (for example, Athanassakos, 2012, 2017; Damodaran, 2005). Last, actuaries like Van Slyke (1999) and Halliwell (2001, 2003) have criticised RARD when the cash flows are stochastic and propose the separation of the time-value of money and the riskiness of those cash flows. In fact, the PV operator should only reflect the time-value of money (as represented by the risk-free rate) and a separate function that could be represented by a certainty equivalent operator (CE) is used to reflect the risk of those cash flows. Moreover, the risk of a business can be separated in the diversifiable and undiversifiable risk, but in many cases value investors hold undiversifiable portfolios, meaning that these concentrated investors can't ignore the idiosyncratic risk. As such, we suggest for the value investing practitioner one of the following methods for risk-adjusting the value, depending on their preferences and assumptions.

4.1.1 Non-diversified portfolios

i. *No-adjustments:* According to Damodaran (2012), the cash flows calculated in a simulation are expected values and hence, they should be discounted at a risk-adjusted discount rate. However, if the investor believes that the standard deviation of the expected value of the investment is an adequate measure of risk then risk-adjusting the discount rate leads to double-counting the risk.

ii. *ZZ Certainty Coefficient Model:* This model was developed by Zhang (2010) and uses option-pricing theory to find the CE Cash Flows by using the volatility of the Cash Flows as a proxy for risk. Given that the CE derivation is based on the Black-Scholes formula for option pricing, it can only be applied to Cash Flows that are normally distributed. The certainty equivalent coefficient according to Zhang's model is:

$$\mathrm{d} = 2\left[1 - \mathrm{N}\left(\sigma\sqrt{{}^{T}\!/_{4}}\right)\right] \qquad (12)$$

$$\text{where} \begin{cases} \mathrm{d} = Certainty\ Equivalent\ Coefficient \\ \sigma = volatility\ of\ cash\ flow \\ T = timing\ of\ the\ cash\ flow \end{cases}$$

4.1.2 Diversified Portfolios

As Halliwell (2001, 2003) has pointed, to count for risk in stochastic cash flows, rather than increasing the discount factor, a transformation of the probability measure of each stochastic cash flow is needed. As we have discussed previously in our small introduction to measure theory, we use the random variable X to "push forward" the probability measure P on (Ω, A) to the probability measure P^X on $\mathbb{R}$. In addition, this probability measure P^X is induced on $\mathbb{R}$ via the cdf F. Hence, by risk-adjusting the cdf F we can adjust the probability measure of the stochastic cash flow.

Although risk-neutral probability measures (denoted $\mathbb{Q}$) have been used by sell-side derivatives specialists for a long-time to price financial derivatives (e.g. Black-Scholes model for European-style options), investors belong to the buy-side and operate with "real" probability measures (denoted $\mathbb{P}$). For a more comprehensive analysis between the $\mathbb{Q}$ and $\mathbb{P}$ see Meucci (2011). As such, the only available methodology we currently have available to risk-adjust probability measures was developed by Wang (2000). Wang has developed a function called distortion function that calculates risk-adjusted probability measures through the application of a transformation commonly known as the Wang transform:

$$F^{*}\ x\ = \Phi\left[\Phi^{1}[F(x)+\lambda]\right] \qquad (13)$$

Where $\begin{cases} \Phi\ is\ the\ standard\ normal\ cdf\ (also\ denoted\ as\ N()) \\ F\ x\ \ is\ the\ cdf\ of\ the\ value\ of\ an\ asset\ X_T, i.e. F\ x\ = \Pr(X_T < x) \\ F^{*}\ x\ is\ the\ risk-adjusted\ cdf\ of\ X_T \\ \lambda\ is\ the\ market\ price\ of\ risk,\ reflecting\ the\ level\ of\ systematic\ risk \end{cases}$

Thus, given the probability distributions of the intrinsic value V, the investor can apply a Wang transformation to the cdf to make the risk-adjustment. For investors that hold well-diversified portfolios, the well-known beta of CAPM can be used as a proxy for systematic risk. For the practitioners that are against the CAPM, other asset pricing models can be used to estimate the level of systematic risk inherent in the asset under examination. Professor Damodaran (2011) has written a series of articles in his personal blog that propose alternatives to CAPM.

Yet, apart from this list that includes CAPM and its alternatives, we would like to bring to the attention of the reader a new promising systematic risk measure that was proposed recently by Kadan et al. (2016). According to their paper, they created a generalized systematic risk measure B_i^R:

$$B_i^R = \frac{R_i\ a^M}{\sum_{h=1}^{n} \alpha_h^M R_h\ \alpha^M} \qquad (14)$$

Where $\begin{cases} a^M = market\ portfolio \\ R\ \bullet\ \ is\ an\ independet, smooth\ and\ convex\ risk\ measure \end{cases}$

If, for example, the risk measure $R\ \bullet$ is the variance then the systematic risk measure becomes the beta of the standard CAPM:

$$B_i^R = \frac{Cov(z_i, a^M \times \boldsymbol{z})}{Var(a^M \times \boldsymbol{z})} \qquad (15)$$

Kadan et al. also provide closed forms for B_i^R so that it incorporates aversion to tail risk, downside risk and rare disasters.

4.1.3 Either Diversified or Concentrated Portfolios

Last, there are two additional methods available to investors that are independent of the degree of diversification in their portfolios.

i. *Haircut Method:* Building on the previous argument about transforming probability measures, the haircut method is an ad-hoc method of adjusting the cash-flows to reflect the riskiness inherent in them. Experience and deep sector knowledge is needed for an investor to successfully apply this method, which can be done in three different ways:

    a. Shift the distribution of the random variables to the left by arbitrarily reducing the mean value of either $\widetilde{FCF}_0$ or V.

    b. Use conservative assumptions for both $\widetilde{FCF}_0$ and G.

    c. Disaggregate $\widetilde{FCF}_0$ into certain and risky and use only the certain ones to calculate the value.

    In all three approaches, we effectively reduce $E[V]$ and hence reduce the probability that $\mathrm{E}[V] > \mathrm{P}$.

ii. *First-Order Certainty Equivalent & Expected Utility:* Under this method that was first suggested by Laffont, an endogenous risk-adjustment is made to each cash flow at time t according to a future utility function:

$$V = \sum_{i=1}^{T} \frac{U^{-1}[\int_{-\infty}^{\infty} U_i[\widetilde{FCF}_\iota + \xi_i] f\ \xi_\iota\ d\xi]}{(1+r_f)^i} \qquad (16)$$

However, as Hughes shows (1995), the risk-adjustment can be deferred to the end of the process if we assume that the current utility function will be applicable in all future periods. The cash flows are adjusted using the risk-free rate and we end up with a pdf of the value V**.** The investor then applies their utility function (e.g. a logarithmic utility function) to find the risk-adjusted $E[V]$.

4.1.4 Asset Based Valuation and Financing Effects

In the case of asset-based valuations we have assumed that book value is non-random and hence, we can identify two different situations:

- *Liquidation Value (*$x_1 = x_5 = 1$*)*: the risk is described by the probability that the market value of liquidated assets will be lower than the one estimated, and the random variable $\widetilde{LVA}$ captures this risk.
- *Reproduction Cost (* $x_1 = x_2 = x_5 = 1$): the risk is defined as the probability that we have overestimated the reproduction costs of the assets of the firm and hence competitors can actually enter the market with lower costs. It is captured by the random variable $\widetilde{RCA}$.

In both those cases, the distributions of $\widetilde{LVA}$ and $\widetilde{RCA}$ are either defined by the analyst alone or through consultation of external valuators, e.g. for a unique type of PP&E asset or intangible assets. As such, a probabilistic approach through a Monte-Carlo method will give us a probability distribution for the random variable V upon which the investor can calculate a broad number of risk measures like high distribution moments (including variance), VaR and CVaR. In addition, the investor needs to consider the effects of financing. In a similar manner to the asset-based valuations, a probabilistic approach through a Monte-Carlo simulation will give us the distribution of the random variable V based on the distributions of $\widetilde{T}, \widetilde{D}, \widetilde{\Pi_B}, \widetilde{BC}\ and\ \widetilde{AC}$. Damodaran (2005, 2012) provides an analytical framework to derive the distribution of such variables, although there are some fundamental issues with the estimation of bankruptcy and agency costs.

If the investor wants to risk-adjust the value calculated through Liquidation, Reproduction cost or the financing effects, then the commonly used method of using risk-adjusted discount rates can't be used in this case, so the investor has three options:

1. *Haircut method:* In a similar fashion with the income approach, conservative assumptions can help the investor mitigate the risk of misestimating $\widetilde{LVA}$ or $\widetilde{RCA}$.
2. *Wang Transformation:* The investor can apply a Wang transform function to the cdf of V.
3. *First-Order Certainty Equivalent & Expected Utility:* Apply a utility function to V to calculate a risk-adjusted $E(V)$.

Last, the activist effect $V\ \mathrm{AP}$ is determined on a case-by-case basis, so no additional comments can be made at this point.

4.2 Margin of Safety

In a deterministic world, every investor should buy an asset when the market price of the stock falls below the intrinsic value of the business:

$$V > P$$

In our stochastic framework, we will compare the mean of the calculated value with the current market price:

$$\mathrm{E}[V] > \mathrm{P} \Rightarrow \mathrm{E}[V] - \mathrm{P} > 0 \quad (17)$$

Value investors focus on the concept of “Margin of Safety” and demand a significant discount to intrinsic value before they invest to protect themselves from the valuation risk inherent in the valuation process. Yet, although this concept is implemented throughout the investing world, there is a lack of academic coverage regarding this aspect. In addition, even practitioners themselves don’t give specific guidance regarding the size of the margin of safety but give only qualitative guidance. That is, they only mention that the higher the uncertainty in the valuation process, the larger the margin of safety required, and vice versa.

We discovered, however, that to quantify the valuation uncertainty, we can use a standardized measure of dispersion in a probability distribution called coefficient of variation (c_v) and is calculated as:

$$c_v = \frac{\sigma}{\mathrm{E}[V]} \qquad (18)$$

Using this coefficient, the investor has the following two options in applying the Margin of Safety principle:

i. *Variability in value distribution.* In the first approach, the investor wants the Margin of Safety to be at least equal to the coefficient of variation, which can be illustrated as:

$$MOS \geq c_v \Rightarrow \frac{\mathrm{E}[V]}{P} - 1 \geq c_v \Rightarrow \mathrm{E}[V] \geq P(1 + c_v) \qquad 19$$

As expected, the higher the coefficient of variation, the larger the discount to intrinsic value should be so that the investor can invest in this stock. In addition, if the distribution of V is skewed to the left and the coefficient of variation underestimates the risk, then the investor can add an extra premium to formula (19) to compensate for this tail-risk that isn't captured by the coefficient.

ii. *Yee's Margin of Safety Model:* The only model that currently exists in the literature about calculating the MOS was developed by Yee (2008) and uses a real-options framework to calculate the appropriate margin of safety. According to Yee, the risks that an investor faces when investing in a security are the market risk (volatility of market price), news risk (news disrupting his calculation of V), valuation risk and convergence risk (how long will it take for the gap between $E[V]$ and P to close). An investor's MOS for going long (we will not examine shorting in this thesis) is calculated as:

$$\Delta_+ = \frac{\delta + \left\{\sqrt{1 + \frac{2}{z}} + 1\right\} z}{1 + \delta} \qquad (20)$$

With: $z = \sigma_s^2 - 2\rho\sigma_s\sigma_v + \sigma_v^2 \; T \big/ 4 \qquad (21)$

Where

$$\begin{cases} \delta = valuation\ risk \\ \sigma_s = prospective\ volatility\ of\ market\ price \\ \sigma_v = prospective\ volatility\ of\ E[\widetilde{V}]\ due\ to\ arrival\ of\ new\ information \\ \rho = correlation\ between\ market\ price\ and\ future\ E[\widetilde{V}] \\ T = expected\ convergence\ time\ between\ P\ and\ E[\widetilde{V}] \end{cases}$$

Yee makes a simplistic illustration in his paper by calculating the value of each asset through the moving average of price-to-book ratio and assuming arbitrarily that $\delta = 0, \sigma_s = \sigma_v = 30\%$, $\rho = 50\%$ and $T = 1$. Instead, we make the following suggestions to the value investing practitioner:

- Use the coefficient of variation as a proxy for valuation risk, i.e. $\delta = c_v$

- Calculate σ_s as implied volatility through the Black-Scholes formula if there are available traded stock options. If there aren't, use historical data for market price volatility.
- The volatility of intrinsic value is lower than the market price volatility, hence ensure that $\sigma_s > \sigma_v$.
- Depending on the situation, $T = 1$ may be overoptimistic, so caution is needed when estimating T. Usually $T \in [1,5]$ for most types of investments.

5. The Coca-Cola Company Case Study

To illustrate all the methods mentioned in Chapters III and IV, we will conduct a case study on the US-listed company named The Coca-Cola Company (NYSE:KO). The Coca-Cola Company (or "The Company" or "Coca-Cola") is a beverage company that manufactures and distributes various non-alcoholic beverages worldwide. It is best known for its core products like Coca-Cola, Coca-Cola Light, Coca-Cola Zero, Fanta, Sprite and Powerade. The company was founded in 1886 and is headquartered in Atlanta, Georgia.

All the data were downloaded by the S&P Capital IQ Platform and the risk analysis was conducted in Microsoft Excel using Palisade's @Risk software for Monte Carlo Simulations. Analytical financial statements of the Coca-Cola Company can be found in Appendixes A. The purpose of the analysis is to implement the framework developed in the previous sessions and should not be regarded as "investment advice" or as a "recommendation" regarding a course of action. Subjective assumptions were made where it was deemed appropriate. All random variables were assumed independent and uncorrelated. All values are in $millions except per share data or if mentioned otherwise.

5.1 Traditional Valuation

Before applying any of the risk-adjusted methods proposed in Chapter IV, we feel that it should be appropriate to first illustrate the usefulness of model (9) using traditional methods of valuation and break down the sources of value for Coca-Cola.

5.1.1 Liquidation Value

To calculate liquidation value, we started with the latest balance sheet available and made the appropriate adjustments ($\widetilde{LVA}$) to book value to estimate the liquidation value. The assumptions we made and the calculated values are presented in Table 1.

Table 1: Liquidation Value Main Assumptions

Liquidation Value					
Period Date	**31/12/2016**	**29/09/2017**	**Recovery Rate**	**Distribution Def**	**Liquidation Value**
ASSETS					
Total Cash & Cash Equivalents	22,201	27,357	100%	1	27,357
Accounts Receivable	3,856	3,664	60-75%	0.675	2,473
Inventory	2,675	2,608	40-50%	0.45	1,174
Prepaid Exp.	1,686	2,721	0%	0	0
Deferred Tax Assets, Curr.	80	0	0%	0	0
Other Current Assets	3,512	2,054	60-75%	0.675	1,386
Total Current Assets	**34,010**	**38,404**			**32,390**
Net PP&E	10,635	8,306	40-60%	0.5	4,153
Long-term Investments	18,569	24,059			0
16.7% Monster Beverage Corp		5,642		52.6	5,376
27.78% Coca-Cola FEMSA		4,648		0.0	0
18% Coca-Cola EP		3,661		0.0	0
23.17% Coca-Cola HBC		2,776		0.0	0
30.81% Coca-Cola Amatil		1,370		0.0	0
16.51% Coca-Cola Bottlers Japan		1,126		0.0	0
26.59% Coca-Cola Bottling Co		536		0.0	0
Other Equity Investments		704		0.0	0
Goodwill	10,629	9,473	0%	0	0
Other Intangibles	10,499	7,091	0%	0	0
Deferred Tax Assets, LT	326	0	0%	0	0
Other Long-Term Assets	2,602	3,182	0%	0	0
Total Assets	**87,270**	**90,515**			**41,919**
LIABILITIES					
Total Liabilities	**64,050**	**68,363**	**100%**		**68,363**

To calculate the Recovery Rate, we used the methodology proposed by Greenwald (2001) and Whitman et. al (2009). Thus, for Cash the recovery rate is 100% while for accounts receivable, inventory, other current assets and Net PP&E the recovery rate is uniformly distributed with the limits presented in column "Recovery Rate". For the rest of the assets we assumed a 0% recovery rate.

The only exception is Monster Beverage, a long-term investment of Coca-Cola that is recorded using the equity method. The difference of Monster with the rest of the investments is that it is a stand-alone company that uses the distribution system of Coca-Cola while all other long-term investments are bottlers for Coca-Cola. The Coca-Cola Company produces only the unsweetened concentrate and then sells it to bottlers that add the sweetener, bottle it and distribute it in their local markets. Hence, we assumed that in case of liquidation of the Company, the equity holdings of Monster Beverage will be little affected, and the liquidators will be able to sell them at market prices. Obviously, trying to sell ~17% of share capital in the open market will probably affect the price, but given Monster's long-term prospects we expect that many willing buyers would appear to take the other side of such a transaction. As such, we used @Risk's fit distribution function on Monster's last year stock price to calculate a distribution of possible sell prices for this stake as can be seen in Exhibit 1.

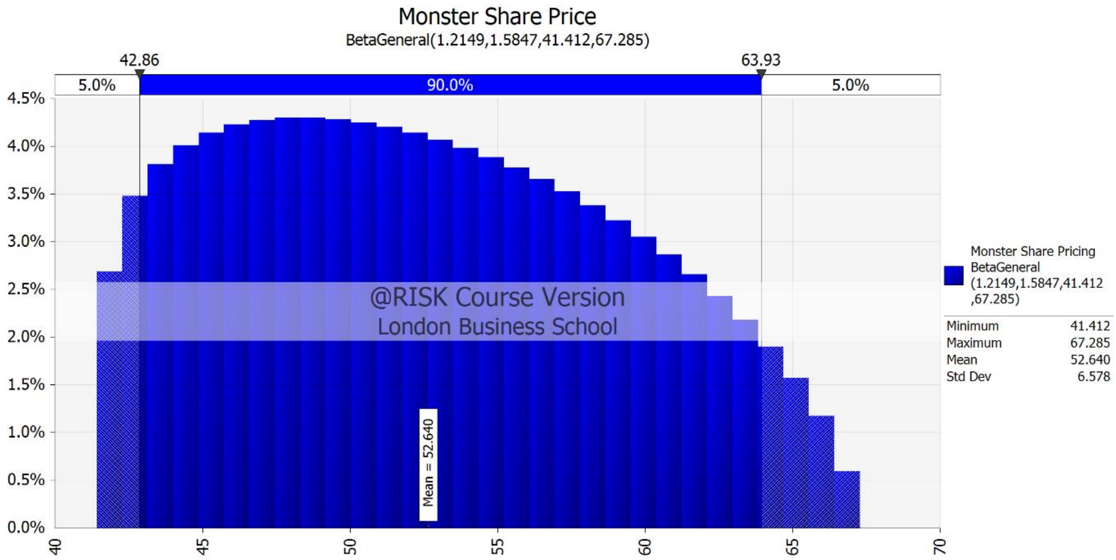

Exhibit 1: Monster Beverage Share Price Distribution

If we run the simulation, we find that liquidation value is negative for all possible scenarios (Exhibit 2), indicating that Coca-Cola is worthless if it seized its operations today.

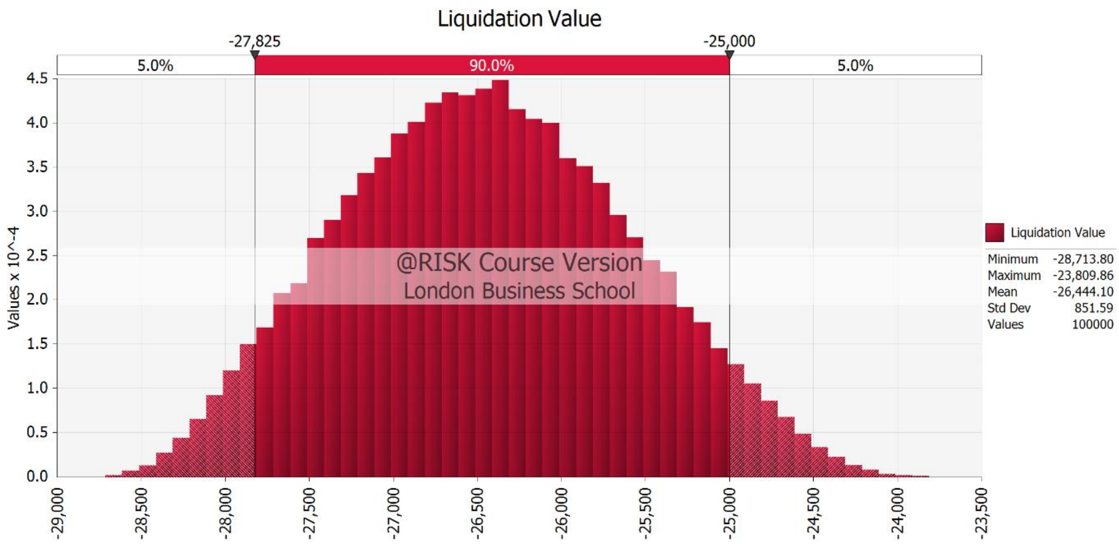

Exhibit 2: Coca-Cola Liquidation Value

5.1.2 Reproduction Costs

For the reproduction costs, we followed again the methodology proposed by Greenwald (2001) and made the appropriate adjustments to book value ($\widetilde{RCA}$). The adjustments we made can be seen in Table 2.

Table 2: Reproduction Cost Main Assumptions

Reproduction Cost

Period Date	31/12/2016	29/09/2017	Adjustments to Arrive at Reproduction Costs	Distribution Def	Reproduction Cost
ASSETS					
Total Cash & Cash Equivalents	22,201	27,357	None	1	27,357
Accounts Receivable	3,856	3,664	Add allowance of $488	1	4,152
Inventory	2,675	2,608	None	1	2,608
Prepaid Exp.	1,686	2,721	None	1	2,721
Deferred Tax Assets, Curr.	80	0	Discount to PV	1	0
Other Current Assets	3,512	2,054	None	1	2,054
Total Current Assets	**34,010**	**38,404**			**38,892**
Net PP&E	10,635	8,306	Gross PP&E	22,218	22,218
Long-term Investments	18,569	24,059			
16.7% Monster Beverage Corp		5,642		53	5,376
27.78% Coca-Cola FEMSA		4,648		75	4,362
18% Coca-Cola EP		3,661		35	3,037
23.17% Coca-Cola HBC		2,776		23	1,956
30.81% Coca-Cola Amatil		1,370		9	12,218
16.51% Coca-Cola Bottlers Japan		1,126		32	1,087
26.59% Coca-Cola Bottling Co		536		210	520
Other Equity Investments		704		1	704
Goodwill	10,629	9,473	None	0	0
Coca-Cola Brand Value	73,102	69,733	None	71,332	71,332
Other Intangibles	10,499	7,091	None	1	7,091
Deferred Tax Assets, LT	326	0	None	1	0
Other Long-Term Assets	2,602	3,182	None	1	3,182
Total Assets	**87,270**	**90,515**			**171,975**
LIABILITIES					
Accounts Payable	2,682	9,983	9,983	1	9,983
Accrued Exp.	5,964	0	0	1	0
Short-term Borrowings	12,498	13,398	13,398	1	13,398
Current Portion of Long Term Debt	3,571	3,264	3,264	1	3,264
Curr. Income Taxes Payable	307	355	355	1	355
Def. Tax Liability, Curr.	692	0	0	1	0
Other Current Liabilities	818	633	633	1	633
Total Current Liabilities	**26,532**	**27,633**	**27,633**		**27,633**
Long-Term Debt	29,732	32,505	32,505	1	32,505
Pension & Other Post-Retire. Benefits	0	0	0	1	0
Def. Tax Liability, Non-Curr.	3,753	4,313	4,313	1	4,313
Other Non-Current Liabilities	4,033	3,912	3,912	1	3,912
Capitalised Leased Obligations				1	0
Total Liabilities	**64,050**	**68,363**	**68,363**		**68,363**

By far the most important aspect of Coca-Cola's assets is its brand value and is significantly different than the goodwill amount, which is just a plug value that is created after an acquisition. To calculate the brand value of Coca-Cola, we used data from a leading company in brand valuation called Interbrand (2017), the same one that Coca-Cola uses for their own commercial purposes. Data are available for the Coca-Cola

Brand Value for the years 2000-2017, and we used them to estimate a probability distribution for the Coca-Cola Brand Value (Exhibit 3).

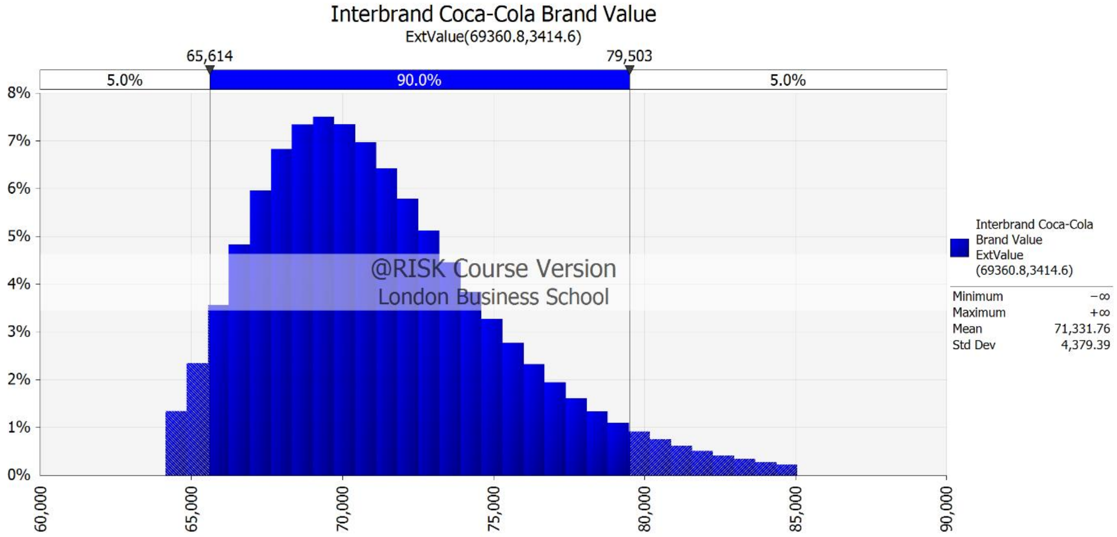

Exhibit 3: Interbrand Coca-Cola Brand Value Distribution

Regarding the Long-term investments recorded using the equity method, we used the same methodology as we did before with Monster, except for “Other Equity Investments” where we could not find all the available data. Last, we opted to not make any adjustments to the liability side because we felt that it wasn’t necessary. The estimated reproduction cost is presented below.

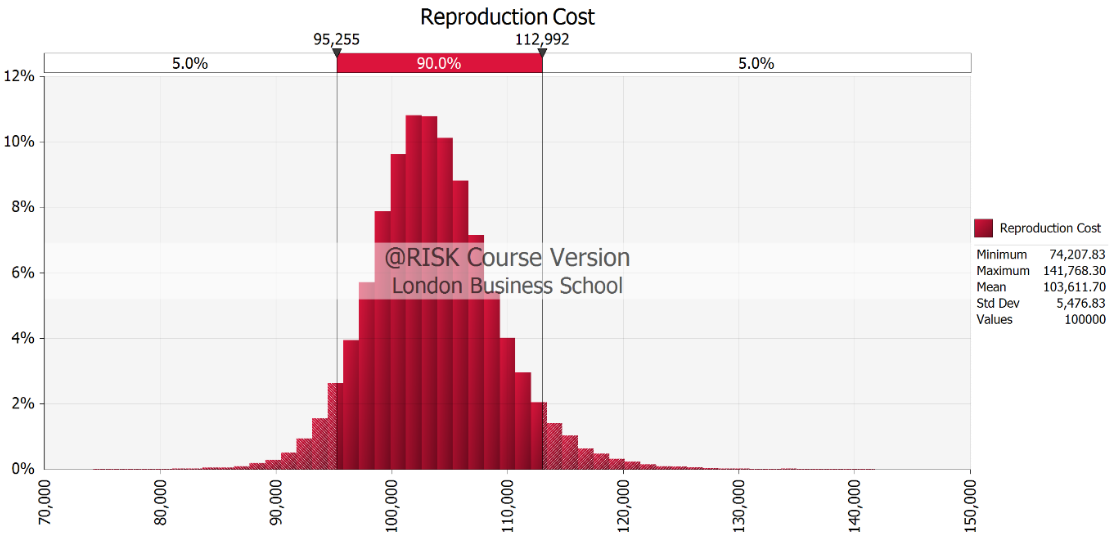

Exhibit 4: Coca-Cola Reproduction Cost Distribution

It is evident that book value on its own significantly underappreciates Coca-Cola's reproduction cost due to the nature of the business and the fact that the Company's largest asset, its brand name, is not recorded on the balance sheet.

5.1.3 Earnings Power

To calculate the earnings power, a traditional DCF analysis is required. The main assumptions of our DCF analysis can be found in Table 3 while extensive calculations are attached in Appendix B.

Table 3: DCF Main Assumptions

DCF Assumptions	
Tax Rate (5 Year Average)	**21.0%**
Risk-Free Rate of Return (Rf)	2.90%
Risk-Free Rate of Return Distribution Def.	2.89%
S&P 500 Market Return (Rm) - Yearly for Last 10 Years	**8.0%**
Size Premium	**0.0%**
D/(D+P+E)	19.8%
D/E	24.6%
Cost of Debt (Rd) - Average of Last 5 Issued Bonds	**1.9%**
Comparable Corporate Yield Curve Rate	**AA**
Choice for Cost of Debt	**Company**
Cost of Preferred (Rp)	**0.0%**

As is proposed by Damodaran (2010, 2012), we identified the four major parameters that drive our valuation and calculated probability distributions for those. The formula to calculate earnings power value is:

$$EPV_{EV} = \frac{Revenue_0 \times Operating\ Margin_0 \ \times (1 - Reinvestment\ Rate_0)}{pre - tax\ WACC}$$

Where $Reinvestment\ Rate_0 = \frac{Net\ CapEX + Additions\ to\ Intangibles + \Delta WC}{Unlevered\ Net\ Income}$

$$EPV_E = EPV_{EV} - Net\ Debt - Minority\ Interest$$

The distributions for the four parameters that affect EPV are presented below:

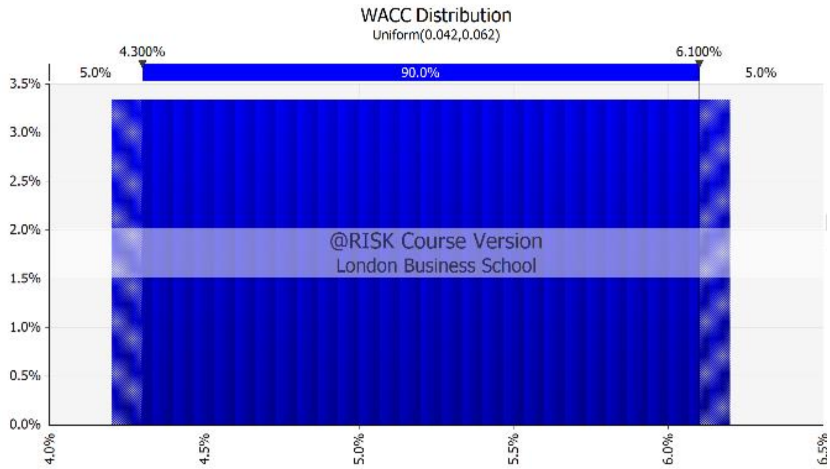

Exhibit 5: WACC Distribution

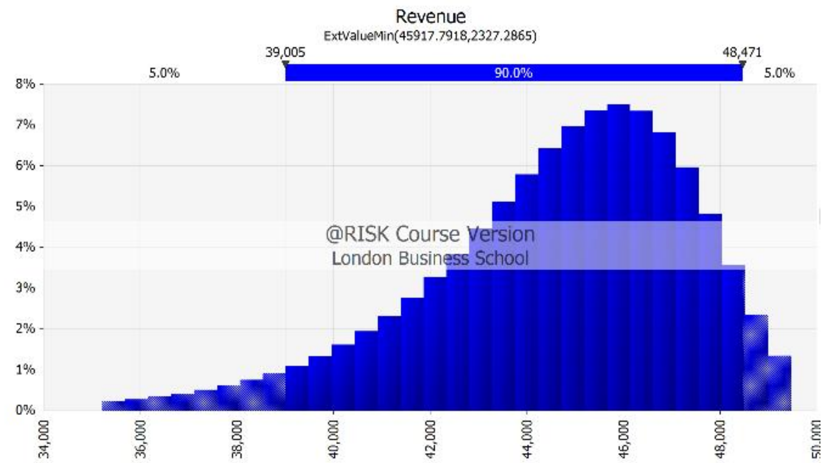

Exhibit 6: Coca-Cola Revenue Distribution

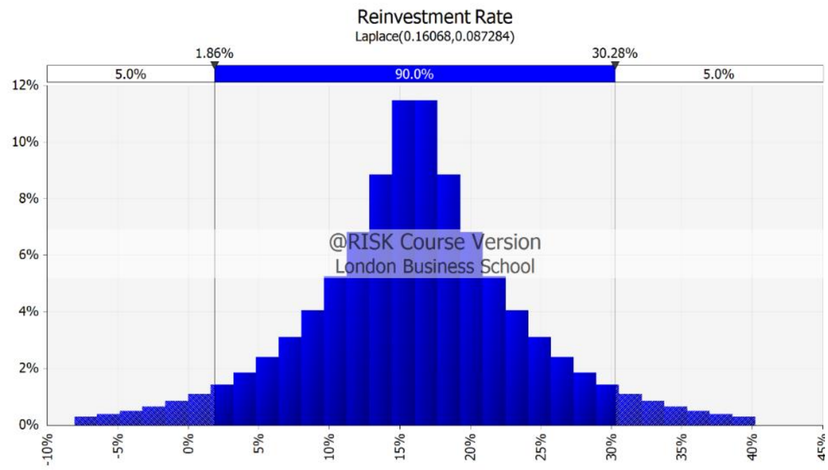

Exhibit 7: Coca-Cola Reinvestment Rate Distribution

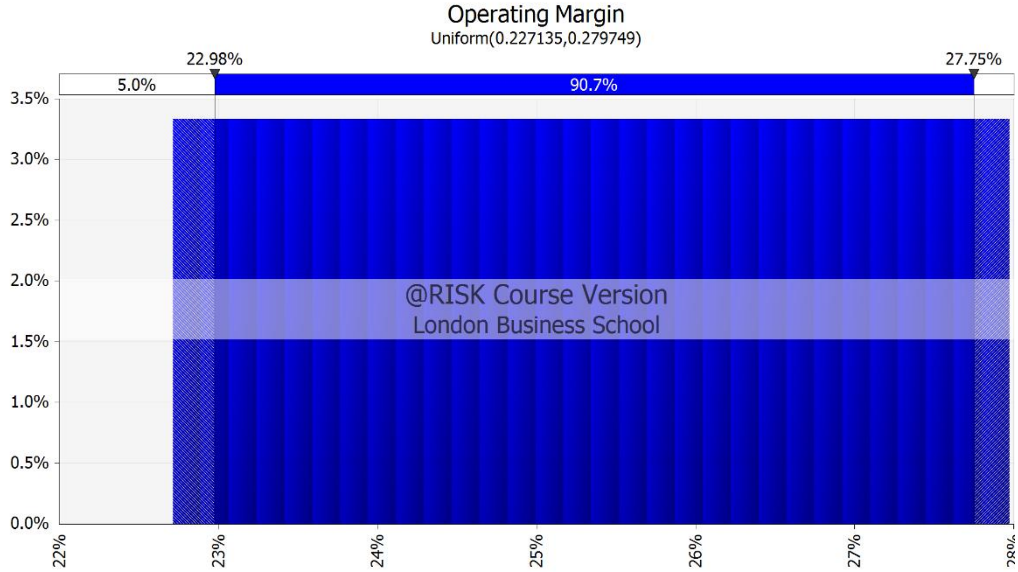

Exhibit 8: Coca-Cola Operating Margin Distribution

The calculated EPV can be seen in Exhibit 9:

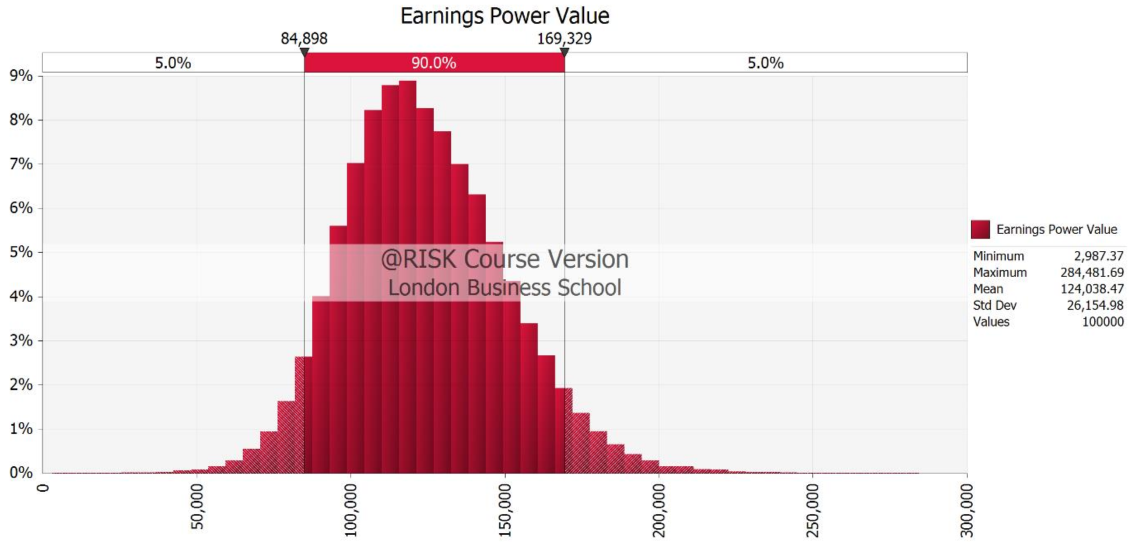

Exhibit 9: Earnings Power Value

5.1.4 Growing Earnings Power

To calculate the Growing Earnings Power Value, we used the following formulas:

$$EPVG_{EV} = \frac{Revenue_0 \times Operating\ Margin_0\ \times\ 1 - Reinvestment\ Rate_0\ \times\ 1 + g}{pre - tax\ WACC - g}$$

$$EPVG_E = EPVG_{EV} - Net\ Debt - Minority\ Interest$$

The distributions for the four parameters are the same as with the previous case and the probability distribution of growth is:

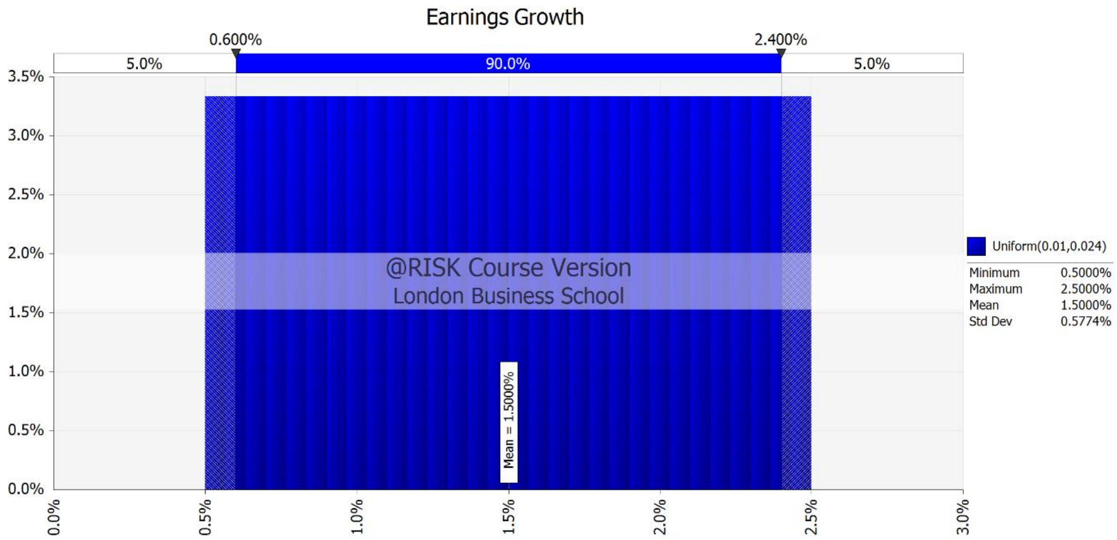

Exhibit 10: Earnings Power Growth Distribution Definition

Hence, the calculated Earnings Power Growth Value is:

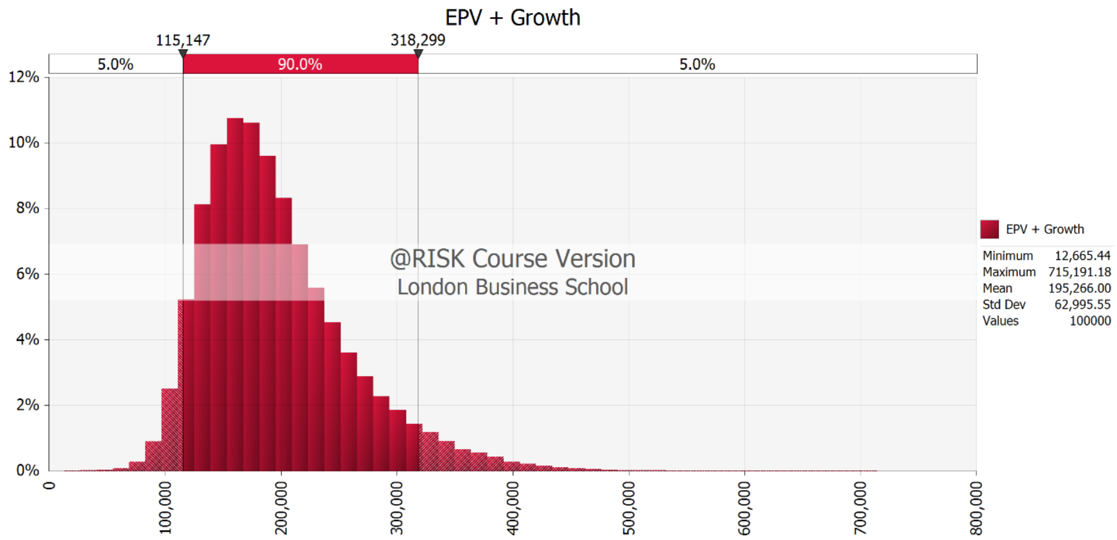

Exhibit 11: Earnings Power Growth Value

5.1.5 Financing Effects

Last, we need to estimate the financing effects. Coca-Cola has a AA-rating and using S&P 500's latest 10 years default rates for AA-rated companies, we can estimate that the default probability is 0%. In addition, we assume that there are no agency costs. Hence, the only effect that financing has on value is through the present value Interest Tax Shield, which we have assumed that is deterministic. The calculations are presented in Table 4:

Table 4: PV of Financing Effects

Value of Financing Effects	
MV of Debt	49,167
Tax Rate	21.0%
Pr of Bankruptcy	0%
Bankruptcy Costs	
PV of Financing Effects	10,325

5.1.6 Summary

To summarize the results, we realize that Coca-Cola is worthless if it is liquidated. In addition, it is valuable to compare the different valuations estimated and their implications. Starting with reproduction cost and earnings power value, we estimated that EPV ($E[EPV] = \$124bn)$ is 20% higher on average than the Reproduction Cost Value ($E[RC] = \$103bn)$, a result that is indicative of a firm that has significant competitive advantages and operates in an industry with high barriers to entry. The positive difference between $E[EPV]$ and $E[RC]$ is called the franchise value of the business. As Greenwald argues, the only kind of growth that adds to a firm's intrinsic value is growth within the franchise, because the sustainable competitive advantages allow the firm to have higher ROIC than its cost of capital. Hence, we can consider the $E[EPVG] = \$195bn$ as sustainable. Adding everything up, we can see the breakdown of the different valuation premiums in exhibit 12:

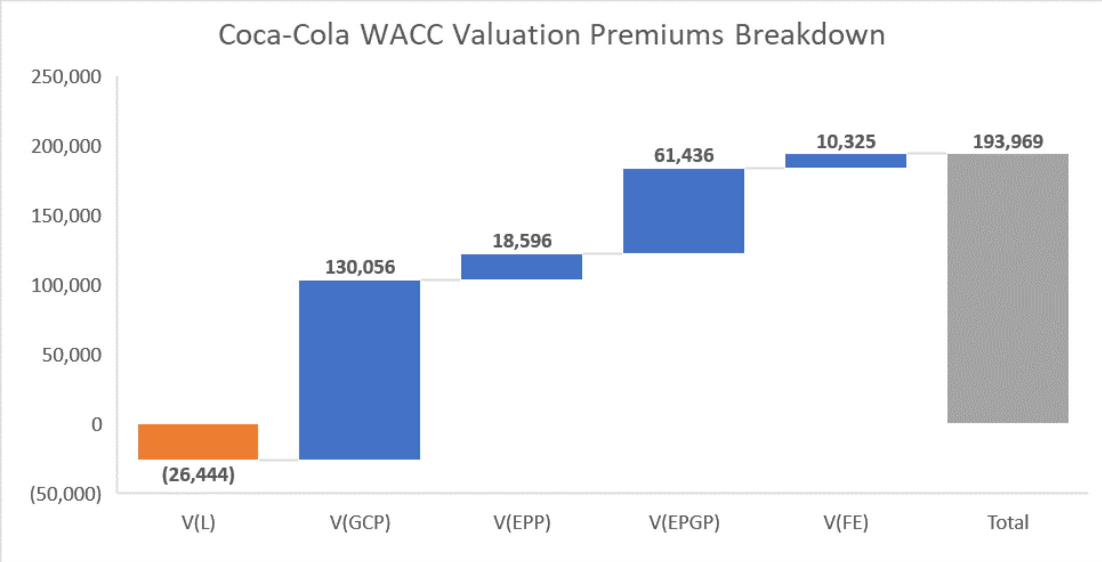

Exhibit 12: Coca-Cola Valuation Breakdown

Finally, while comparing this value with the current market cap (18/01/2018), we will need to apply a Margin of Safety. As discussed above, the two different methods to calculate the MOS is either the coefficient of variation or Yee's model. The coefficient of variation is $c_v = 31\%$ while the inputs for Yee's model are presented in Tables 5 and 6. As a proxy for the prospective volatility of the market price σ_s we used the implied volatility in the Black-Scholes formula for options pricing and calculated it using available options data from the NASDAQ Stock Exchange:

Tables 5 & 6: Yee's Margin of Safety Calculation

Yee MOS Model Inputs	
σ_s	14.6%
σ_v	10.0%
ρ	50.0%
T	5.00
z	0.02
δ	31%
Δ+	**41%**
Δ-	38%

Implied Volatility Calculation	
Option Type	Call
Underlying Price (19/01/2018)	$47.16
Exercise Price	$50
Days Until Expiration	730
Risk-Free Rate	2.9%
Dividend Yield	3.1%
Option Market Price	$2.5
Implied Volatility	**14.6%**

We also assumed that $\sigma_v = 10\%$ to ensure that $\sigma_s > \sigma_v$ while we set $\rho = 50\%$ following Yee's examples in his own paper. The valuation risk is captured by the Coefficient of variation, i.e. $\delta = c_v = 31\%$ while the investment horizon was set to $T = 5\ years$. The effect on Investment Value ($Intrinsic\ Value - Current\ Price$) for 18th January 2018 and $Current\ Price = \$46.88$ is demonstrated below:

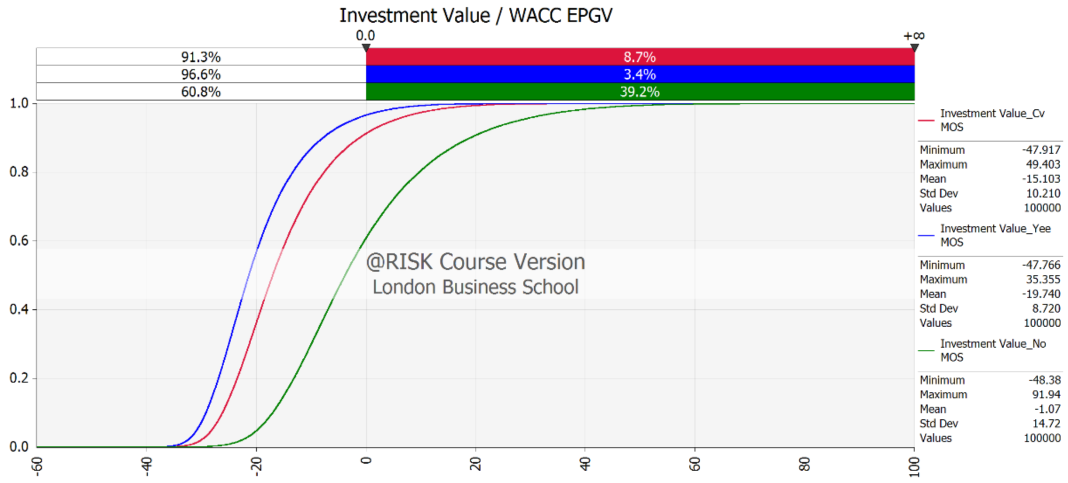

Exhibit 13: Investment Value - MOS Application

Exhibit 13 clearly illustrates that if we do not apply a margin of safety then Coca-Cola seems fairly valued. However, a value investor always applies a margin of safety before investing and we can see that after applying it there is only a small chance that Coca-Cola is undervalued based on the assumptions we made, even when we factor in growth.

5.2 Dealing with Risk – Applications

In the upcoming subchapters, we will present the applications of the models proposed in Section III for the Coca-Cola Company. As we have seen in the chapter 5.1, Coca-Cola operates in an industry with high barriers to entry and has substantial competitive advantages. Hence, we will assume that $x_1 = x_2 = x_3 = x_4 = x_5 = 1$ while $x_6 = 0$ in formula 9, meaning that we will use the EPV Growth and Financial Effects as random variables to value Coca-Cola. Unless mentioned otherwise, the assumptions for revenue, reinvestment rate and operating margins are the same as previously. In addition, since the EPV Growth formula is a growing perpetuity, we decided to use the 30-Year US Treasury Rate as a proxy for the risk-free and we assumed it is triangularly distributed:

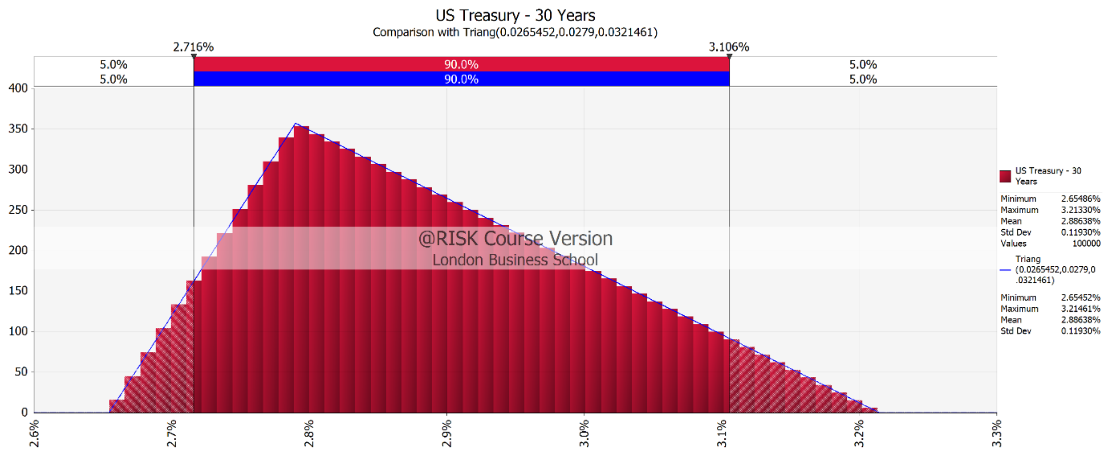

Exhibit 14: Risk-free rate distribution definition

An investor that believes that risk-free rates will be higher in the future could model the risk-free rate using a different distribution with a higher mean and different parameters. The value of financing effects ($10,325m) is considered constant in all methodologies presented. For each method applied we calculated the Coefficient of Variation C_v and the Yee's Margin of Safety and based on the distribution of the total equity value. The individual results for each method are available in Appendix C.

5.2.1 No-adjustments Approach

Under the no-adjustments methodology, we do not make any adjustments to our previous assumptions and discount the unlevered Free Cash Flows using the risk-free rate. Under this methodology, Coca-Cola seems fairly value or slightly undervalued, depending on the margin of safety an investor requires.

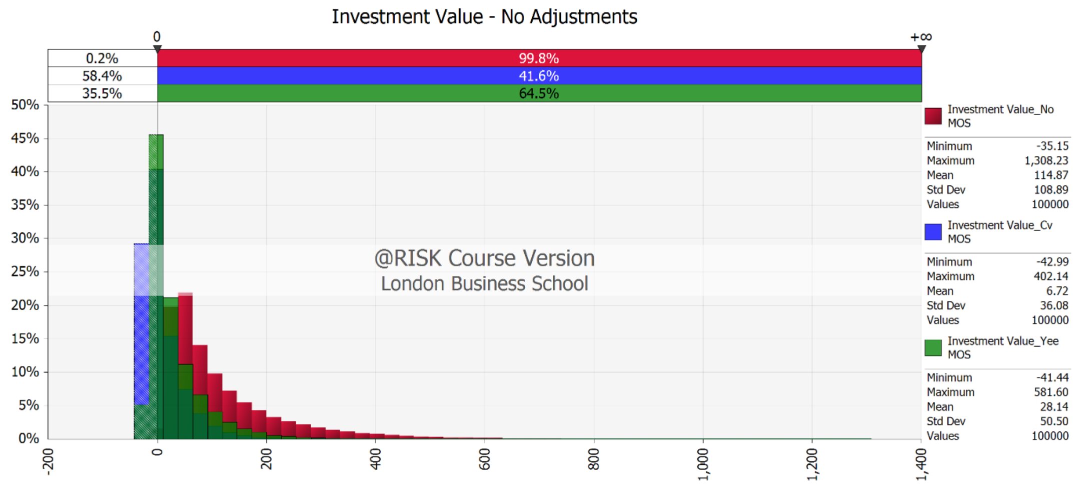

Exhibit 15: Investment Value - No Adjustments

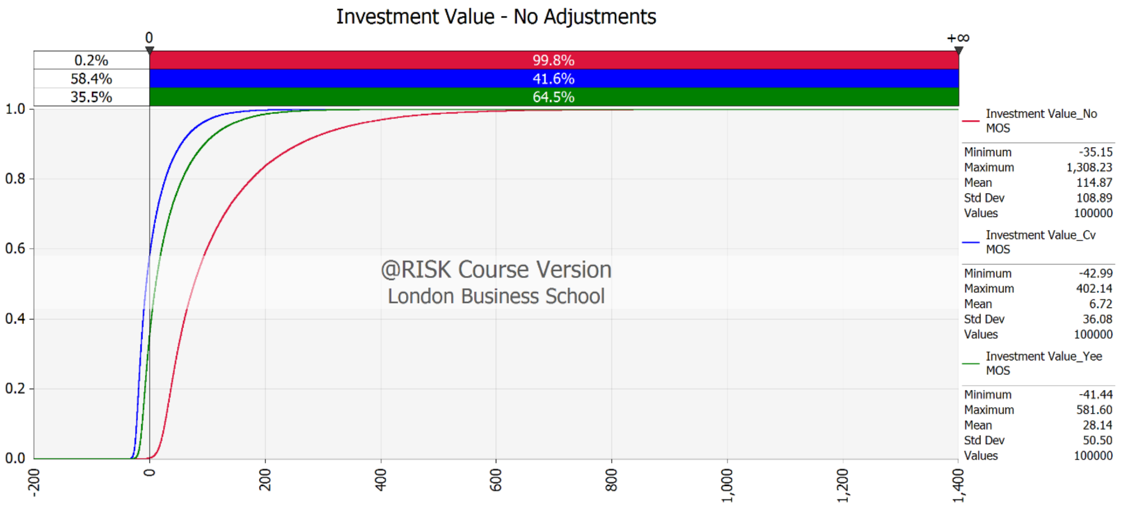

Exhibit 16: Cdf of Investment Value - No Adjustments

The usefulness of treating the investment value as a stochastic variable is evident in this approach for Coca-Cola. If an investor considers the coefficient of variation as an adequate proxy to calculate the Margin of Safety, then for $c_v = 67\%$ this investment has $E[\widetilde{I}] = \$6.72$, yet we see that 58.4% of the observations are negative due to the positive skewness of the distribution.

5.2.2 ZZ Certainty Equivalent Model

To apply the ZZ Certainty equivalent model, we need to assume that the Unlevered FCF is normally distributed. Using the Unlevered FCF from the years 2010-2017 and fitting a normal distribution, we end-up with the assumption that $FCF_0 \sim N(6{,}886.99{,}618.92)$.

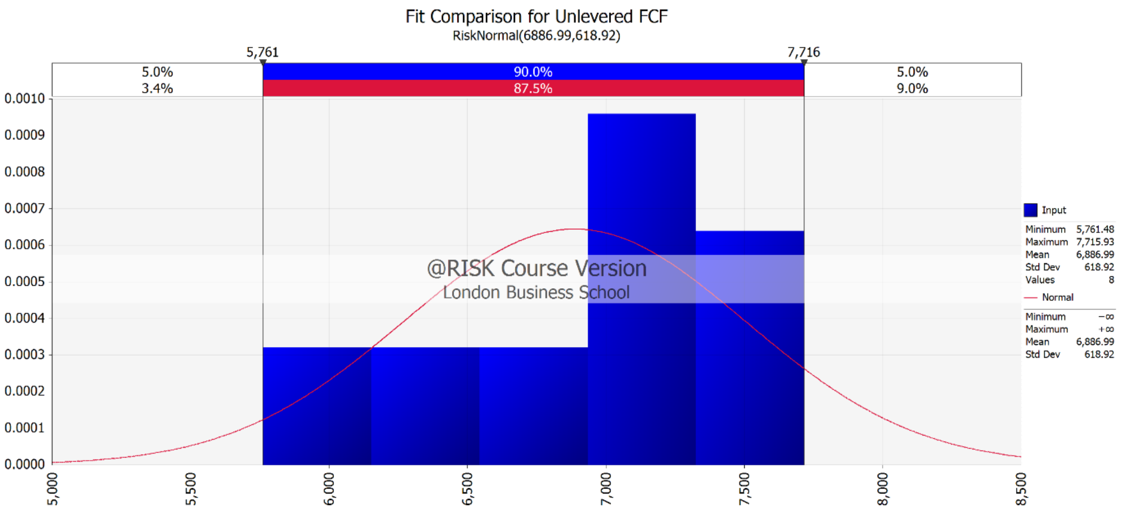

Exhibit 17: Normally Distributed Unlevered FCF

What's more, the Certainty Equivalent Coefficient (formula 12) depends on the volatility of the cash-flows and the timing of each cash-flow, meaning that we can't use the closed-form perpetuity formula as in the rest of the methods. Hence, we projected the cash flows until the year 400 (after that the contribution of each cash flow to PV is immaterial) and applied the CE coefficient to each one of those cash flows. An illustration of the evolution of the CE Coefficient and the PV operator ($PV_t \bullet \ = \frac{1}{(1+r_f)^t}$) is available in Exhibit 18.

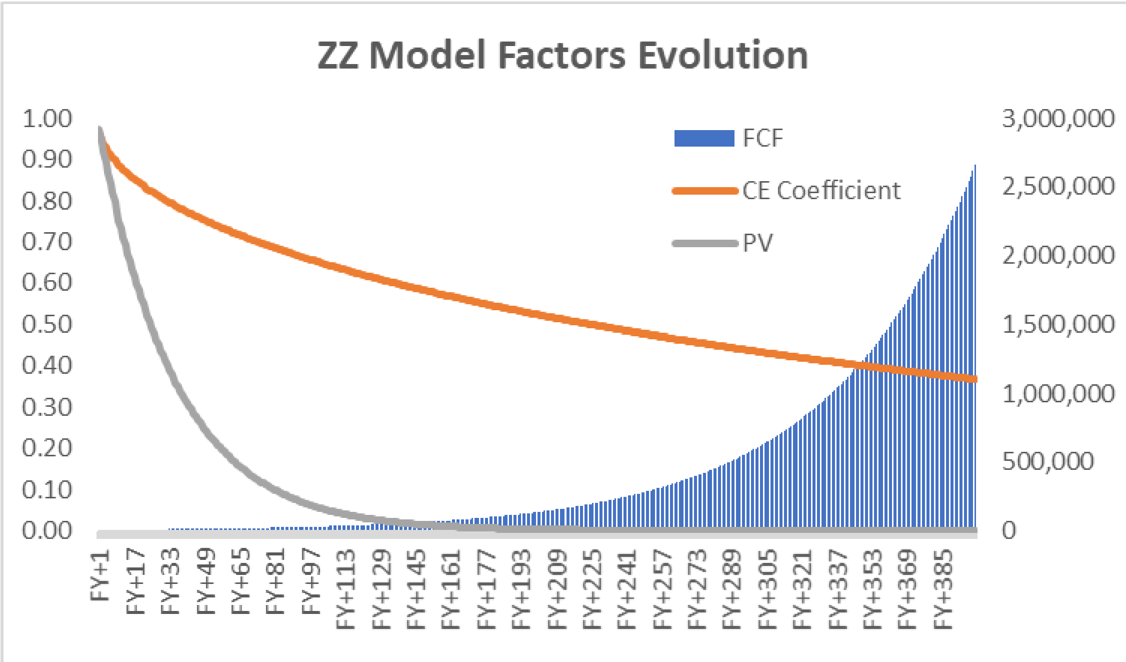

Exhibit 18: ZZ Model Factors Evolution

As we can see from Exhibits 19 and 20, Coca-Cola is undervalued in all situations. If, however, we apply a MOS, then the expected value of our investment drops from $48.2 to $4-$6 dollars, with more than half of the observations being negative, indicating that a risk-averse value investor wouldn't invest in Coca-Cola based on its current price.

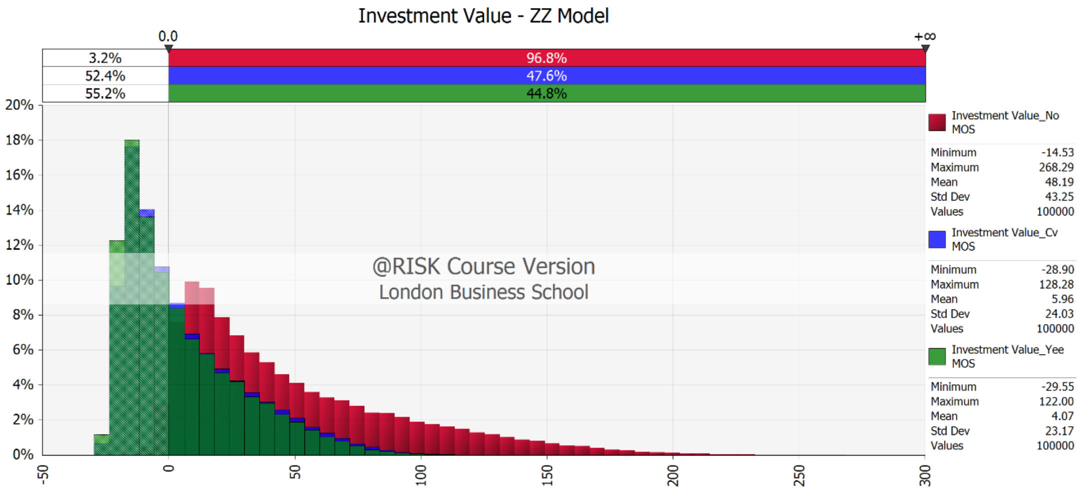

Exhibit 19: Investment Value - ZZ Certainty Equivalent Model

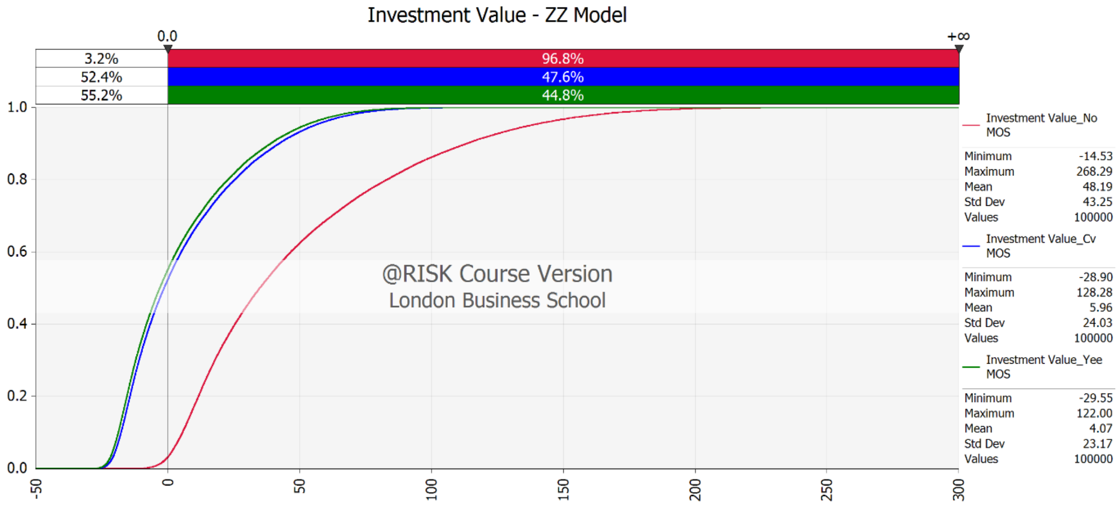

Exhibit 20: Cdf of Investment Value - ZZ CE Model

5.2.3 Wang Transformation

Wang's transformation is a transformation of the cdf of the Investment Value depending on a factor λ, which is a proxy for the systematic risk of the investment. In Exhibit 21 we demonstrate how an original cdf is transformed for three different levels of systematic risk. By examining this graph, we realise that Wang's transform shifts the distribution to the left by increasing the Z-score $\Phi^{-1}[F\ x\ -\lambda]$ of lower-valued observations, i.e. increasing their probability of occurrence according to the exposure of those observations to systematic risk as it is captured through the parameter λ.

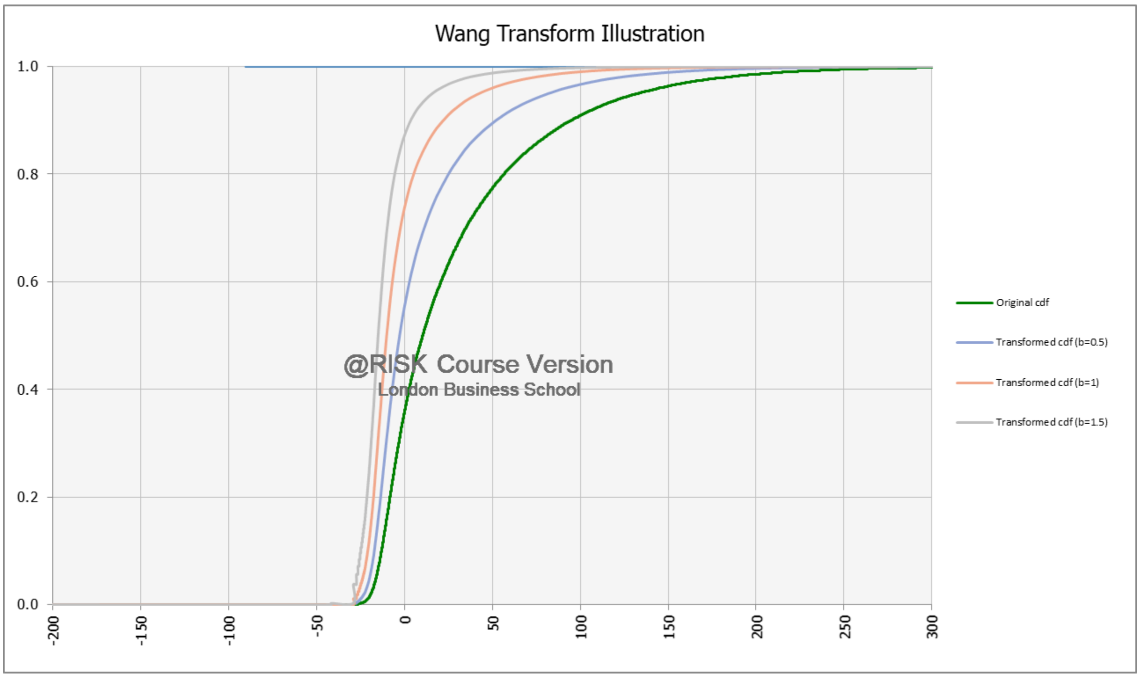

Exhibit 21: Wang Transformation Illustration

Applying the Wang Transform in the three cdfs of Investment Value, we end up with the following results:

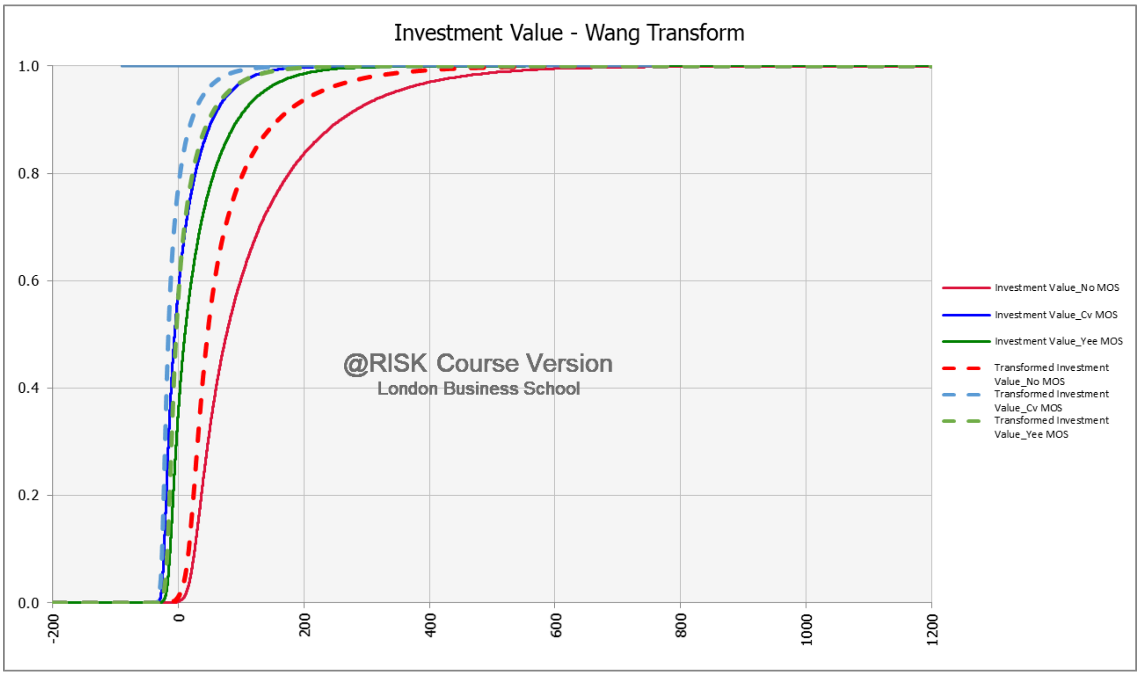

Exhibit 22: Cdf of Investment Value - Wang Transformation

For no_MOS, the probability of negative Investment Value is 1.2%, for c_v_MOS is 77.6% and for Yee_MOS it is 57.2%. Hence, we conclude again that a risk-averse value investor wouldn't invest in Coca-Cola at the current price levels.

5.2.4 Haircut Methodology

To apply the Haircut method, we combined two of the three available approaches. First, we assumed that the sustainable long-term earnings are 50%-75% of our original assumptions (approach a), distribution shifting) and that their perpetual growth G will be uniformly distributed between 0.5%-1.5% (conservative assumptions) as is shown below:

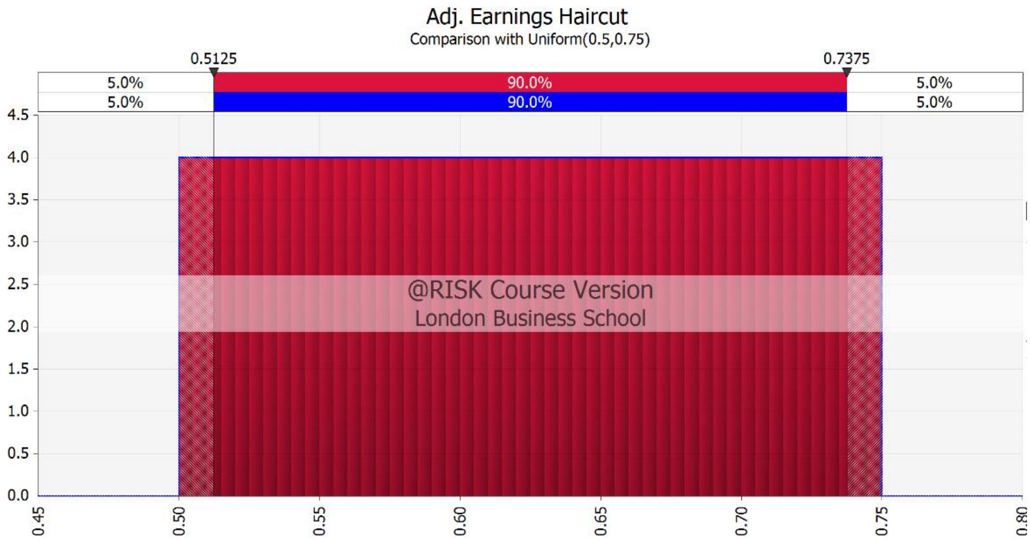

Exhibit 23: Adjusted Earnings Haircut Distribution

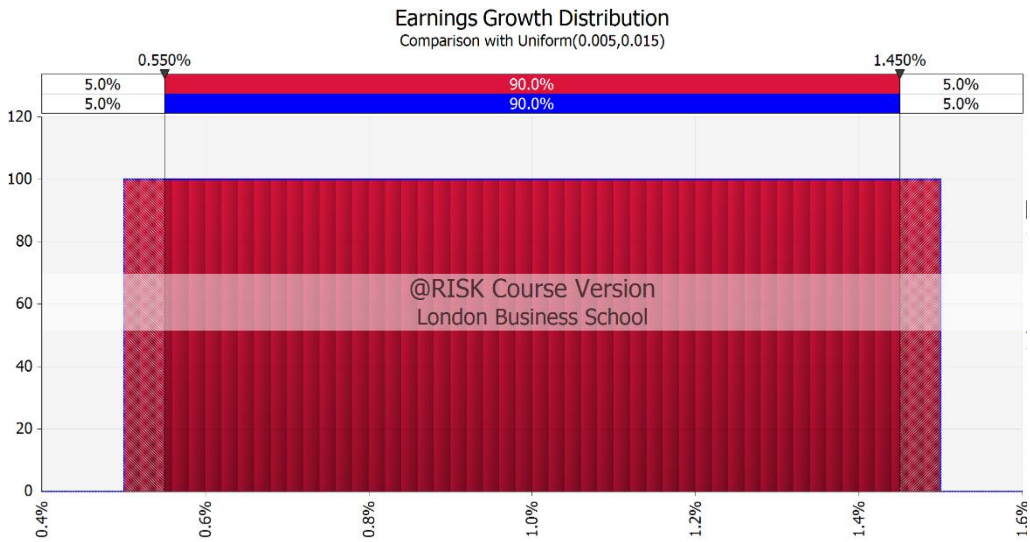

Exhibit 24: Adjusted Earnings Conservative Growth Distribution

With the haircut method, Coca-Cola seems more overvalued rather than fairly-valued, even if we don’t apply a margin of safety.

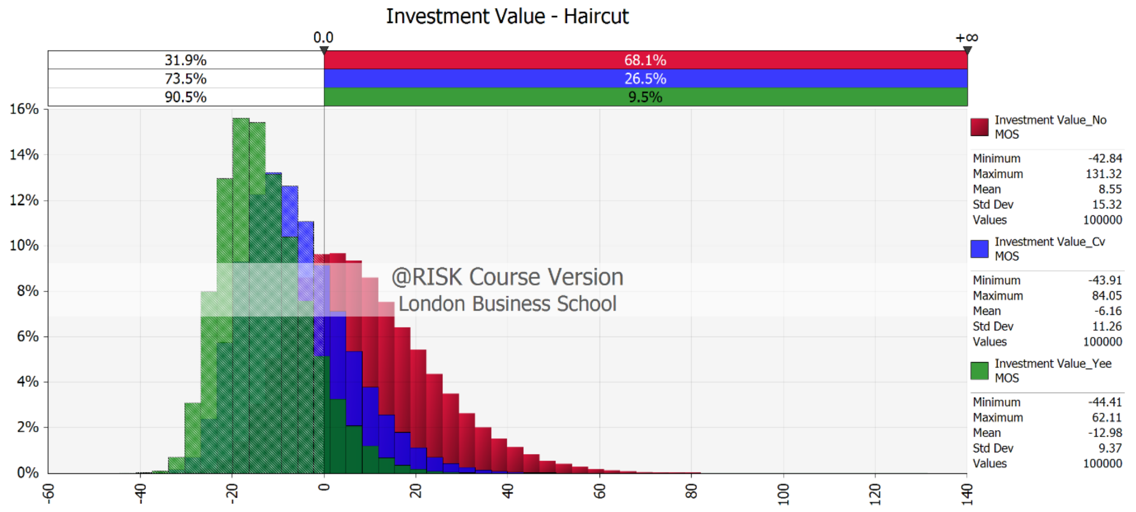

Exhibit 25: Investment Value - Haircut Method

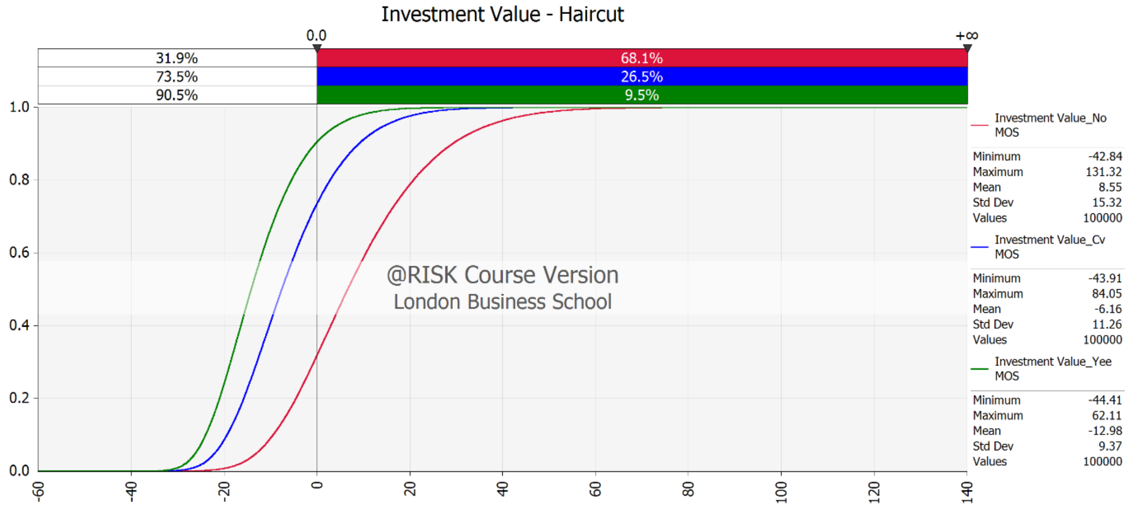

Exhibit 26: Cdf of Investment Value - Haircut Method

5.2.5 Expected Utility Approach

Finally, the expected utility approach allows us to calculate the certainty equivalent for the expected Investment Value$E[I]$, but we don’t get more information about the distribution of Investment Value. The distribution of V under our normal assumptions is depicted in Exhibit 27.

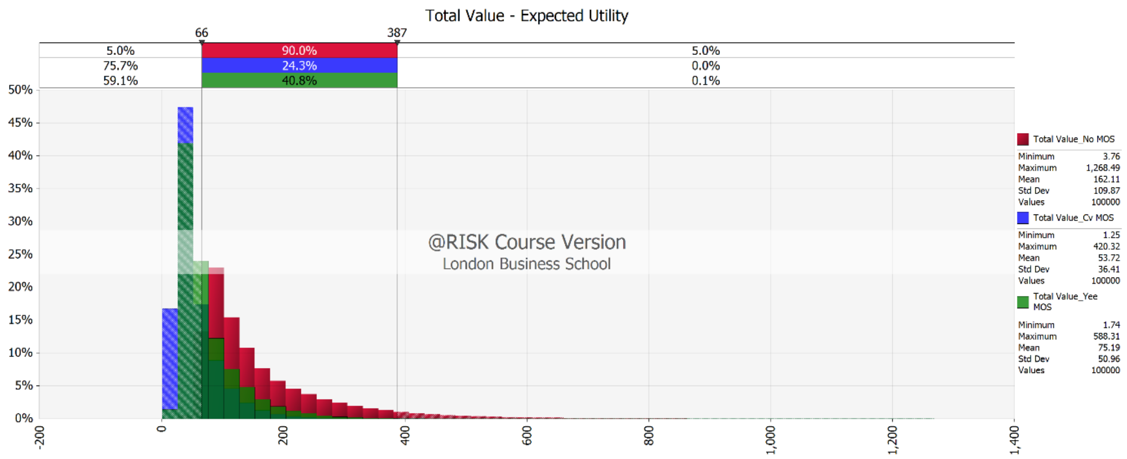

Exhibit 27: Total Value - Expected Utility Method

Using the information on this exhibit, we can calculate the certainty equivalent for the three different distributions by applying a utility function to the distribution. In our case, we opted to use a logarithmic utility function, i.e. u(x)=ln(x) but an investor can apply their own utility function depending on their preferences and risk-aversion. The results of our calculation can be seen in Table 7.

Table 7: Expected Utility Method Investment Value

Expected Utility Method Investment Value			
	No_MOS	Cv_MOS	Yee_MOS
E[V]	162.1	53.7	75.2
CE(E[V])	123.6	28.8	50.0
-Total Debt	(11.5)	(11.5)	(11.5)
-Preferred Stock	0.0	0.0	0.0
-Minority Interest	(0.0)	(0.0)	(0.0)
+Cash & Equivalents	6.4	6.4	6.4
Equity Intrinsic Value	**118.5**	**23.6**	**44.9**
-Current Price	46.9	46.9	46.9
Investment Value	**71.6**	**(23.3)**	**(2.0)**

5.3 Results Summary and Analysis

A synopsis of the results from the application of all the different proposed methods for dealing with risk are presented in the next page:

Table 8: Methods Application Summary Results

Method	Cv	Yee's MOS	Investment Value No MOS	Investment Value Cv MOS	Investment Value Yee's MOS
WACC	31%	41%	(3.78)	(16.98)	(21.35)
No Adjustments	67%	54%	76.71	(5.93)	10.44
ZZ Cert. Equiv.	44%	46%	34.78	(1.50)	(3.12)
Haircut	27%	39%	6.83	(7.42)	(14.03)
Wang Transform	67%	54%	71.59	(7.62)	8.07
Exp. Utility	67%	54%	123.59	40.95	57.32

The fist thing we notice by examining the results summary is that the WACC method is the only one that suggests that Coca-Cola is slightly overvalued (negative investment value) even if we don't apply any type of Margin of Safety. In contrast, the Expected Utility method suggests that Coca-Cola is an attractive investment even after we apply a significant MOS. For the rest of the methods, depending on which model we use to calculate the MOS, Coca-Cola's attractiveness as an investment varies significantly. Last, we detect a tendency for the Yee's MOS model to oscillate around 50% based on our assumptions, being higher than the Coefficient of Variation when $c_v < 50\%$ and less when $c_v > 50\%$.

Based on the results for the Coca-Cola case, one could argue that the WACC method underestimates Coca-Cola's value, either because we estimated a high risk-adjusted discount rate or due to other shortcomings of the method. On the other hand, someone else could argue that since WACC is the most commonly accepted method, all other methods misestimate the value of The Company. The truth is that both arguments are flawed because no-one can give a definite answer. Different methods make different assumptions and are based on different economic theories.

The WACC method is commonly accepted because as Halliwell says "it moves with the inertia of the world", where everyone thinks in terms of rates of interest and rates of return. On the contrary, the rest of the methods force the analyst to focus primarily on cash-flows, which should be the most important part of every DCF analysis. The no-adjustments method, although practically easy to develop, considers both systematic and unsystematic risk, although even a small number of investments is enough to decrease dramatically the effect of undiversifiable risk. The ZZ Certainty Equivalent requires normally-distributed cash flows, an assumption that is hard to find in the real world. The advantage of the haircut method is that it is appealing both from a theoretical and practical perspective. Yet, as the adjustments to cash flows are subjective, not only the analyst needs to have substantial knowledge to attempt such a venue, but they also need to be accurate in their assumptions to be profitable. The Wang transform, especially with the prospects the new Generalized Systematic Risk measure that is under development offers the best theoretical approach to risk-adjusting cash flows by adjusting their probability measures. However, until more applications are developed, it is still subject to all the limiting issues that CAPM suffers from. Last, the Expected Utility method is also based on a strong theoretical framework, but issues like selecting the appropriate utility function or even developing a model for stochastic utility could increase complications exponentially. Yet, despite their shortcomings, all those models could prove useful to the seasoned value investor and should be included in their valuation toolkit.

6. Conclusions

In this thesis we have developed an analytical framework for dealing with risk under the strategy of value investing. We broke down the uncertainty inherent in the valuation process and created a stochastic valuation formula that separates the different sources of value for a company. We also departed from the traditional practice of using risk-adjusted discount rates and suggested a handful of different approaches an investor can follow to deal with valuation risk. In addition, we provided two quantitative methods to calculate the Margin of Safety and showed the sources for the inputs of those two methods. Last, we conducted a case study for the listed US company “The Coca-Cola Company” and applied the framework developed in the previous chapters, illustrating the differences between the different methods proposed.

As Damodaran argues, the process of valuation is neither an art, nor a science, it is a craft. And although we haven’t touched upon that issue, every quantitative framework for valuation should be accompanied by a comprehensive qualitative framework. All quantitative valuation models, stochastic and deterministic, share the same disadvantage: garbage in, garbage out. The assumptions that the analyst makes and the story they attach to each valuation process is equally, if not more important than the model they will eventually use. By using our stochastic valuation framework to identify the different sources of value of a company and focusing on cash flows rather than discount rates, we aim with this thesis to turn the analyst’s attention to the true drivers of the value of a company and force them to double-think their assumptions, because, at the end of the day, these assumptions will drive their investment performance.

Bibliography

[1] Athanassakos, G. (2012). The value investor's strategy for choosing the right stocks. *The Globe and Mail*, [Online]. Available at: https://www.theglobeandmail.com/globe-investor/investor-education/what-do-value-investors-believe-in/article32477971/

[2] Athanassakos, G. (2012). Value Investing Vs. Modern Portfolio Theory. *Journal of Business & Financial Affairs*, Vol. 1, No. 2, pp. 1-2.

[3] Athanassakos, G. (2017). A value investor's take on diversification and risk. *The Globe and Mail*, [Online]. Available at: https://www.theglobeandmail.com/globe-investor/investment-ideas/a-value-investors-take-on-diversification-and-risk/article27266235/

[4] Athanassakos, G. (2017). Value investing and risk: What you will not learn at university. *The Globe and Mail*, [Online]. Available at: https://www.theglobeandmail.com/globe-investor/investor-education/a-view-of-risk-not-shared-in-academia/article35685921/

[5] Brealey, R.A., Myers, S.C. and Allen, F. (2016). *Principles of corporate finance.* 12th International edition. McGraw-Hill Education, Maidenhead.

[6] Browne, C. (2006). *Little book of value investing.* Wiley, Hoboken, NJ.

[7] Buffett, W., (1984). The Superinvestors of Graham-and-Doddsville. Hermes, the Columbia Business School Magazine. [Online] Available at: https://www8.gsb.columbia.edu/rtfiles/cbs/hermes/Buffett1984.pdf

[8] Canada, J. R., and White, J. A. (1980). *Capital investment decision analysis for management and engineering*. Englewood Cliffs, NJ: Prentice-Hall.

[9] Carlisle, T.E. (2014). *Deep value: why activist investors and other contrarians battle for control of losing corporations.* Wiley, Hoboken, NJ.

[10] Cassidy, A., Radgers, L., and McCarthy, W. (1970). A Simulation Approach to Risk Assessment in Investment Analysis. *Review of Marketing and Agricultural Economics.*

[11] Damodaran, A. (2006). Valuation approaches and metrics: a survey of the theory and evidence. *Foundations and Trends in Finance*, vol. 1, no. 8, pp. 693-784.

[12] Damodaran, A. (2010). *The Dark Side of Valuation: Valuing Young, Distressed, and Complex Businesses.* 2nd Edition. Financial Times Prentice Hall.

[13] Damodaran, A. (2011). *The series on alternatives to the CAPM.* [Online] Available at: http://aswathdamodaran.blogspot.co.uk/2011/04/alternatives-to-capm-part-1-relative.html

[14] Damodaran, A. (2012). *Value Investing: Investing for Grown Ups?*. [Online] Available at http://dx.doi.org/10.2139/ssrn.2042657.

[15] Damodaran, A. (2012). *Investment Valuation: Tools and Techniques for Determining the Value of Any Asset*. 3rd Edition. John Wiley and Sons.

[16] Damodaran, A. (2013). Living with Noise: Valuation in the Face of Uncertainty. *Journal of Applied Finance*, vol. 23, no. 2, pp. 6.

[17] Graham, B., and Dodd, D. (1934). *Security Analysis.* Whittlesey House, New York: McGraw-Hill Book Co.

[18] Graham, B. (1949). *The Intelligent Investor: A Book of Practical Counsel.* New York: Harper & Row.

[19] Greenblatt, J. (2006). *The Little Book That Beats the Market*. Wiley, Hoboken.

[20] Greenblatt, J. (2016). *Magic Formula Investing.* [Online] Available at: https://www.magicformulainvesting.com/

[21] Greenwald, B.C., Kahn, J. and Sonkin, P.D. (2001). *Value investing: from Graham to Buffett and beyond*. Wiley, New York.

[22] Haley, C.W. (1984). Valuation And Risk-Adjusted Discount Rates. *Journal of Business Finance & Accounting*, vol. 11, no. 3, pp. 347-353

[23] Halliwell, L. (2003). The Valuation of Stochastic Cash Flows. *Casualty Actuarial Society Forum*, Reinsurance Discussion Papers, pp. 1-68.

[24] Halliwell, L. (2001). A Critique of Risk-Adjusted Discounting. *ASTIN Colloquim*. [Online] Available at: http://www.casact.org/coneduc/reinsure/astin/2000/halliwell1.doc

[25] Hawas, F., and Cifuentes, A. (2014). Valuation of Projects with Stochastic Cash Flows and Intertemporal Correlations: Practical Modeling Guidelines. *Journal of Construction Engineering and Management*, Vol. 140, Issue 6.

[26] Hertz, D. B. (1964). Risk analysis in capital investment. *Harvard Business Review*, 42(1): pp. 95–106.

[27] Hertz, David B. (1968). Investment Policies That Pay Off. *Harvard Business Review*, pp. 96-108.

[28] Hillier, F. S. (1963). The derivation of probabilistic information for the evaluation of risky investments. *Management Science*, 9(3), pp. 443–457.

[29] Hillier, F. S. (1969). *The evaluation of risky interrelated investments*. Amsterdam: North-Holland.

[30] Hughes, W.T. (1995). Risk analysis and asset valution: A Monte Carlo Simulation using stochastic rents. *The Journal of Real Estate Finance and Economics*, vol. 11, no. 2, pp. 177-187.

[31] Interbrand (2017). Coca-Cola Brand Value Growth History, electronic dataset, viewed 19 January 2018, http://interbrand.com/best-brands/best-global-brands/2017/ranking/cocacola/

[32] Johar, K., Carmichael, D., and Balatbat, M. (2010). A Study of Correlation Aspects in Probabilistic NPV Analysis. *The Engineering Economis*t, Vol. 55, Iss. 2, pp. 181-199.

[33] Kadan, O., Liu, F. and Liu, S. (2016). Generalized Systematic Risk. *American Economic Journal: Microeconomics*, vol. 8, no. 2, pp. 86-127.

[34] Kim, S. H., Hussein, H. E., and Kim, D. J. (1999). Derivation of an intertemporal correlation coefficient model based on cash flow components and probabilistic evaluation of a project's NPV. *The Engineering Economist*, 44(3), pp. 276–294.

[35] Klarman, S. (1991). *Margin of Safety: Risk-Averse Value Investing Strategies for the Thoughtful Investor.* New York: HarperCollins.

[36] Klarman, S. (2009). *Presentation at the Ben Graham Centre for Value Investing, Richard Ivey School of Business.* [Online] Available at:

[37] https://www.ivey.uwo.ca/bengrahaminvesting/news/2009/03/seth-klarman-speaks-to-ivey-value-investing-class/

[38] Luehrman, T.A. (1997). *Using APV (adjusted present value): a better tool for valuing operations.* Harvard Business School Press, UNITED STATES.

[39] Luehrman, T.A. (1997). *What's it worth? A general manager's guide to valuation.* Harvard Business School Press, UNITED STATES.

[40] Lewellen, W.G. (1977). Some Observations on Risk-Adjusted Discount Rates. *The Journal of Finance*, vol. 32, no. 4, pp. 1331-1337.

[41] Maged, A., Haddadeh, R., Eldabi, T., and Mansour, E. (2010). Simulation discounted cash flow valuation for Internet companies. *International Journal of Business Information Systems*.

[42] McKinsey & Company Inc, Koller, T. and Goedhart, M. (2015). *Valuation*. Wiley.

[43] McLennan, M.B. (2011). Seeking a Margin of Safety and Valuation. *CFA Institute Conference Proceedings Quarterly*, vol. 28, no. 2, pp. 27-34.

[44] Meucci, A., (2011). 'P' Versus 'Q': Differences and Commonalities between the Two Areas of Quantitative Finance. *GARP Risk Professional*, pp. 47-50. Available at SSRN: https://ssrn.com/abstract=1717163

[45] Modigliani, F. and Miller, M. (1958). The Cost of Capital, Corporation Finance and the Theory of Investment. *The American Economic Review*, vol. 48, pp. 261.

[46] Modigliani, F. and Miller, M. (1961). Dividend Policy, Growth, and the Valuation of Shares. *The Journal of Business, 34*(4), 411-433.

[47] Modigliani, F. and Miller, M. (1963). Corporate income taxes and the cost of capital. *American Economic Review*, Vol. 53, no. 3, pp. 433–43.

[48] Myers, S.C. (1974). Interactions of Corporate Financing and Investment Decisions-Implications for Capital Budgeting. *The Journal of Finance*, vol. 29, no. 1, pp. 1-25.

[49] Richardson, J., and Mapp, H. (1976). Use of Probabilistic Cash Flows in Analyzing Investments Under Conditions of Risk and Uncertainty. *Journal of Agricultural and Applied Economics*, 8(2), 19-24.

[50] Robichek, A.A. and Myers, S.C. (1966). *Conceptual Problems in the Use of Risk-Adjusted Discount Rates. The Journal of Finance*, vol. 21, no. 4, pp. 727-730.

[51] Ruback, R. S. (2000). *Capital Cash Flows: A Simple Approach to Valuing Risky Cash Flows*. Mimeo.

[52] Schwab, B. (1978). Conceptual Problems In The Use Of Risk-Adjusted Discount Rates With Disaggregated Cash Flows. *Journal of Business Finance & Accounting*, vol. 5, no. 4, pp. 281-293.

[53] Stewart, G.B. (1991). *The Quest for Value: A Guide for Senior Managers*. New York, NY: HarperCollins, Publishers.

[54] Swirles, J., and Lusztig, P. (1968). Capital Expenditure Decisions Under Uncertainty. *Cost and Management*, pp. 13-19.

[55] Taylor, H.M. and Karlin, S. (1998). *Introduction to stochastic modelling.* 3rd edition. Academic Press, San Diego, Calif.

[56] Tufekci, S., and Young, D.B. (1987). Moments of the Present Worths of General Probabilistic Cash Flows Under Random Timing. *The Engineering Economist*, Vol. 32, Iss. 4, pp. 303-336.

[57] Van Slyke, O., (1999). The Cost of Capital: An Axiomatic Approach. *Actuarial Considerations Regarding Risk and Return in Property-Casualty Insurance Pricing*, CAS, pp. 135-164.

[58] Wagle, B. (1967). A statistical analysis of risk in capital investment projects. *Operational Research Society*, 18(1), pp. 13–33.

[59] Wang, S. (2000). A Class of Distortion Operators for Pricing Financial and Insurance Risks. *The Journal of Risk and Insurance*, vol. 67, no. 1, pp. 15-36.

[60] Whitman, M.J., Diz, F. and D'Aniello, D. (2009). *Distress Investing Principles and Technique.* John Wiley & Sons Inc, Hoboken.

[61] Yee, K.K. (2008). Deep-Value Investing, Fundamental Risks, and the Margin of Safety. *Journal of Investing*, vol. 17, no. 3, pp. 35-46.

[62] Young, D., and Contreras, L. (1975). Expected Present Worths of Cash Flows Under Uncertain Timing. *The Engineering Economist*, Vol. 20, Iss. 4, pp. 257-268.

[63] Zhang, Z. (2010). Certainty equivalent, risk premium and asset pricing. *Frontiers of Business Research in China*, vol. 4, no. 2, pp. 325-339.

Appendix A – Coca Cola Financial Statements

Appendix Table 1: Income Statement

THE COCA-COLA COMPANY (NYSE:KO)

INCOME STATEMENT - USD IN MILLIONS												LTM
Period Date	**31/12/2006**	**31/12/2007**	**31/12/2008**	**31/12/2009**	**31/12/2010**	**31/12/2011**	**31/12/2012**	**31/12/2013**	**31/12/2014**	**31/12/2015**	**31/12/2016**	**29/09/2017**
Revenues	24,088	28,857	31,944	30,990	35,119	46,542	48,017	46,854	45,998	44,294	41,863	37,307
Cost Of Goods Sold	8,160	10,406	11,374	11,088	12,693	18,204	19,053	18,421	17,889	17,482	16,465	14,361
Gross Profit	**15,928**	**18,451**	**20,570**	**19,902**	**22,426**	**28,338**	**28,964**	**28,433**	**28,109**	**26,812**	**25,398**	**22,946**
Selling General & Admin Exp.	9,431	10,945	11,774	11,358	13,120	17,422	17,738	17,310	17,218	16,427	15,262	13,240
Other Operating Expense/(Income)	0	254	0	0	341	4	10	18	24	145	392	150
Other Operating Exp., Total	**9,431**	**11,199**	**11,774**	**11,358**	**13,461**	**17,426**	**17,748**	**17,328**	**17,242**	**16,572**	**15,654**	**13,390**
Operating Income	**6,497**	**7,252**	**8,796**	**8,544**	**8,965**	**10,912**	**11,216**	**11,105**	**10,867**	**10,240**	**9,744**	**9,556**
Interest Expense	(220)	(456)	(438)	(355)	(733)	(417)	(397)	(463)	(483)	(856)	(733)	(879)
Interest and Invest. Income	193	236	333	267	317	483	515	604	645	696	697	737
Net Interest Exp.	**(27)**	**(220)**	**(105)**	**(88)**	**(416)**	**66**	**118**	**141**	**162**	**(160)**	**(36)**	**(142)**
Income / (Loss) from Affiliates	102	668	(874)	781	1,025	690	819	602	769	489	835	1,040
Currency Exchange Gains (Loss)	(15)	(10)	24	80	(45)	(73)	(2)	(22)	(197)	176	(174)	(84)
Other Non-Operating Inc. (Exp.)	(30)	2	23	(115)	48	14	(7)	28	9	25	10	20
EBT Excl Unusual Items	**6,527**	**7,692**	**7,864**	**9,202**	**9,577**	**11,609**	**12,144**	**11,854**	**11,610**	**10,770**	**10,379**	**10,390**
Restructuring Charges	(24)	0	(249)	(273)	(343)	(275)	(423)	(682)	(845)	(983)	(592)	(520)
Merger & Related Restruct. Charges	0	0	0	0	(209)	(393)	6	0	0	0	0	0
Impairment of Goodwill	0	0	0	0	0	0	0	(82)	0	0	(10)	(385)
Gain (Loss) On Sale Of Invest.	298	143	(127)	57	4,688	593	292	25	45	(22)	101	58
Gain (Loss) On Sale Of Assets	0	84	119	0	597	0	0	615	(799)	709	(1,154)	(2,184)
Asset Writedown	(112)	0	(38)	(40)	0	0	0	(113)	(18)	(473)	(143)	(539)
Legal Settlements	0	0	0	0	0	0	0	0	0	0	0	(43)
Other Unusual Items	(111)	0	(63)	0	(103)	(76)	(210)	(140)	(668)	(396)	(445)	(457)
EBT Incl Unusual Items	**6,578**	**7,919**	**7,506**	**8,946**	**14,207**	**11,458**	**11,809**	**11,477**	**9,325**	**9,605**	**8,136**	**6,320**
Income Tax Expense	1,498	1,892	1,632	2,040	2,370	2,812	2,723	2,851	2,201	2,239	1,586	1,773
Earnings from Cont. Ops.	**5,080**	**6,027**	**5,874**	**6,906**	**11,837**	**8,646**	**9,086**	**8,626**	**7,124**	**7,366**	**6,550**	**4,547**
Earnings of Discontinued Ops.	0	0	0	0	0	0	0	0	0	0	0	0
Extraord. Item & Account. Change	0	0	0	0	0	0	0	0	0	0	0	0
Net Income to Company	**5,080**	**6,027**	**5,874**	**6,906**	**11,837**	**8,646**	**9,086**	**8,626**	**7,124**	**7,366**	**6,550**	**4,547**
Minority Int. in Earnings	0	(46)	(67)	(82)	(50)	(62)	(67)	(42)	(26)	(15)	(23)	3
Net Income to Parent	**5,080**	**5,981**	**5,807**	**6,824**	**11,787**	**8,584**	**9,019**	**8,584**	**7,098**	**7,351**	**6,527**	**4,550**

Appendix Table 2: Common Size Income Statement

THE COCA-COLA COMPANY (NYSE:KO)

INCOME STATEMENT												LTM
Period Date	**31/12/2006**	**31/12/2007**	**31/12/2008**	**31/12/2009**	**31/12/2010**	**31/12/2011**	**31/12/2012**	**31/12/2013**	**31/12/2014**	**31/12/2015**	**31/12/2016**	**29/09/2017**
Revenues	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Cost Of Goods Sold	33.9%	36.1%	35.6%	35.8%	36.1%	39.1%	39.7%	39.3%	38.9%	39.5%	39.3%	38.5%
Gross Profit	**66.1%**	**63.9%**	**64.4%**	**64.2%**	**63.9%**	**60.9%**	**60.3%**	**60.7%**	**61.1%**	**60.5%**	**60.7%**	**61.5%**
Selling General & Admin Exp.	39.2%	37.9%	36.9%	36.7%	37.4%	37.4%	36.9%	36.9%	37.4%	37.1%	36.5%	35.5%
Other Operating Expense/(Income)	0.0%	0.9%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.9%	0.4%
Other Operating Exp., Total	**39.2%**	**38.8%**	**36.9%**	**36.7%**	**38.3%**	**37.4%**	**37.0%**	**37.0%**	**37.5%**	**37.4%**	**37.4%**	**35.9%**
Operating Income	**27.0%**	**25.1%**	**27.5%**	**27.6%**	**25.5%**	**23.4%**	**23.4%**	**23.7%**	**23.6%**	**23.1%**	**23.3%**	**25.6%**
Interest Expense	-0.9%	-1.6%	-1.4%	-1.1%	-2.1%	-0.9%	-0.8%	-1.0%	-1.1%	-1.9%	-1.8%	-2.4%
Interest and Invest. Income	0.8%	0.8%	1.0%	0.9%	0.9%	1.0%	1.1%	1.3%	1.4%	1.6%	1.7%	2.0%
Net Interest Exp.	**-0.1%**	**-0.8%**	**-0.3%**	**-0.3%**	**-1.2%**	**0.1%**	**0.2%**	**0.3%**	**0.4%**	**-0.4%**	**-0.1%**	**-0.4%**
Income / (Loss) from Affiliates	0.4%	2.3%	-2.7%	2.5%	2.9%	1.5%	1.7%	1.3%	1.7%	1.1%	2.0%	2.8%
Currency Exchange Gains (Loss)	-0.1%	0.0%	0.1%	0.3%	-0.1%	-0.2%	0.0%	0.0%	-0.4%	0.4%	-0.4%	-0.2%
Other Non-Operating Inc. (Exp.)	-0.1%	0.0%	0.1%	-0.4%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
EBT Excl Unusual Items	**27.1%**	**26.7%**	**24.6%**	**29.7%**	**27.3%**	**24.9%**	**25.3%**	**25.3%**	**25.2%**	**24.3%**	**24.8%**	**27.9%**
Restructuring Charges	-0.1%	0.0%	-0.8%	-0.9%	-1.0%	-0.6%	-0.9%	-1.5%	-1.8%	-2.2%	-1.4%	-1.4%
Merger & Related Restruct. Charges	0.0%	0.0%	0.0%	0.0%	-0.6%	-0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Impairment of Goodwill	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	0.0%	0.0%	0.0%	-1.0%
Gain (Loss) On Sale Of Invest.	1.2%	0.5%	-0.4%	0.2%	13.3%	1.3%	0.6%	0.1%	0.1%	0.0%	0.2%	0.2%
Gain (Loss) On Sale Of Assets	0.0%	0.3%	0.4%	0.0%	1.7%	0.0%	0.0%	1.3%	-1.7%	1.6%	-2.8%	-5.9%
Asset Writedown	-0.5%	0.0%	-0.1%	-0.1%	0.0%	0.0%	0.0%	-0.2%	0.0%	-1.1%	-0.3%	-1.4%
Legal Settlements	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
Other Unusual Items	-0.5%	0.0%	-0.2%	0.0%	-0.3%	-0.2%	-0.4%	-0.3%	-1.5%	-0.9%	-1.1%	-1.2%
EBT Incl Unusual Items	**27.3%**	**27.4%**	**23.5%**	**28.9%**	**40.5%**	**24.6%**	**24.6%**	**24.5%**	**20.3%**	**21.7%**	**19.4%**	**16.9%**
Income Tax Expense	6.2%	6.6%	5.1%	6.6%	6.7%	6.0%	5.7%	6.1%	4.8%	5.1%	3.8%	4.8%
Earnings from Cont. Ops.	**21.1%**	**20.9%**	**18.4%**	**22.3%**	**33.7%**	**18.6%**	**18.9%**	**18.4%**	**15.5%**	**16.6%**	**15.6%**	**12.2%**
Earnings of Discontinued Ops.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Extraord. Item & Account. Change	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Net Income to Company	**21.1%**	**20.9%**	**18.4%**	**22.3%**	**33.7%**	**18.6%**	**18.9%**	**18.4%**	**15.5%**	**16.6%**	**15.6%**	**12.2%**
Minority Int. in Earnings	0.0%	-0.2%	-0.2%	-0.3%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	0.0%
Net Income to Parent	**21.1%**	**20.7%**	**18.2%**	**22.0%**	**33.6%**	**18.4%**	**18.8%**	**18.3%**	**15.4%**	**16.6%**	**15.6%**	**12.2%**

Appendix Table 3: Balance Sheet

THE COCA-COLA COMPANY (NYSE:KO)

BALANCE SHEET - USD IN MILLIONS												LTM
Period Date	**31/12/2006**	**31/12/2007**	**31/12/2008**	**31/12/2009**	**31/12/2010**	**31/12/2011**	**31/12/2012**	**31/12/2013**	**31/12/2014**	**31/12/2015**	**31/12/2016**	**29/09/2017**
ASSETS												
Cash And Equivalents	2,440.0	4,093.0	4,701.0	7,021.0	8,517.0	12,803.0	8,442.0	10,414.0	8,958.0	7,309.0	8,555.0	12,528.0
Short Term Investments	150.0	215.0	278.0	2,192.0	2,820.0	1,232.0	8,109.0	9,854.0	12,717.0	12,591.0	13,646.0	14,829.0
Trading Asset Securities	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	14.0	20.0	0.0	0.0
Total Cash & ST Investments	**2,590.0**	**4,308.0**	**4,979.0**	**9,213.0**	**11,337.0**	**14,035.0**	**16,558.0**	**20,268.0**	**21,689.0**	**19,920.0**	**22,201.0**	**27,357.0**
Accounts Receivable	2,587.0	3,317.0	3,090.0	3,758.0	4,430.0	4,920.0	4,759.0	4,873.0	4,466.0	3,941.0	3,856.0	3,664.0
Total Receivables	**2,587.0**	**3,317.0**	**3,090.0**	**3,758.0**	**4,430.0**	**4,920.0**	**4,759.0**	**4,873.0**	**4,466.0**	**3,941.0**	**3,856.0**	**3,664.0**
Inventory	1,641.0	2,220.0	2,187.0	2,354.0	2,650.0	3,092.0	3,264.0	3,277.0	3,100.0	2,902.0	2,675.0	2,608.0
Prepaid Exp.	1,292.0	1,798.0	1,606.0	1,624.0	2,205.0	2,614.0	1,989.0	2,400.0	1,902.0	1,884.0	1,686.0	2,721.0
Deferred Tax Assets, Curr.	117.0	238.0	119.0	118.0	478.0	227.0	244.0	211.0	160.0	151.0	80.0	0.0
Other Current Assets	214.0	224.0	195.0	484.0	479.0	609.0	3,514.0	275.0	1,669.0	4,597.0	3,512.0	2,054.0
Total Current Assets	**8,441.0**	**12,105.0**	**12,176.0**	**17,551.0**	**21,579.0**	**25,497.0**	**30,328.0**	**31,304.0**	**32,986.0**	**33,395.0**	**34,010.0**	**38,404.0**
Gross Property, Plant & Equipment	11,911.0	14,444.0	14,400.0	16,467.0	21,706.0	23,151.0	23,486.0	25,032.0	25,258.0	22,354.0	21,256.0	16,730.0
Accumulated Depreciation	(5,008.0)	(5,951.0)	(6,074.0)	(6,906.0)	(6,979.0)	(8,212.0)	(9,010.0)	(10,065.0)	(10,625.0)	(9,783.0)	(10,621.0)	(8,424.0)
Net Property, Plant & Equipment	**6,903.0**	**8,493.0**	**8,326.0**	**9,561.0**	**14,727.0**	**14,939.0**	**14,476.0**	**14,967.0**	**14,633.0**	**12,571.0**	**10,635.0**	**8,306.0**
Long-term Investments	6,783.0	7,777.0	5,779.0	6,755.0	7,662.0	8,693.0	11,454.0	12,659.0	14,839.0	16,868.0	18,569.0	24,059.0
Goodwill	1,403.0	4,256.0	4,029.0	4,224.0	11,665.0	12,219.0	12,255.0	12,312.0	12,100.0	11,289.0	10,629.0	9,473.0
Other Intangibles	3,732.0	7,963.0	8,476.0	8,604.0	15,244.0	15,450.0	15,082.0	15,299.0	14,272.0	12,843.0	10,499.0	7,091.0
Deferred Tax Assets, LT	168.0	66.0	83.0	96.0	98.0	243.0	403.0	328.0	319.0	360.0	326.0	0.0
Other Long-Term Assets	2,533.0	2,609.0	1,650.0	1,880.0	1,946.0	2,933.0	2,176.0	3,186.0	2,874.0	2,670.0	2,602.0	3,182.0
Total Assets	**29,963.0**	**43,269.0**	**40,519.0**	**48,671.0**	**72,921.0**	**79,974.0**	**86,174.0**	**90,055.0**	**92,023.0**	**89,996.0**	**87,270.0**	**90,515.0**
LIABILITIES												
Accounts Payable	929.0	1,380.0	1,370.0	1,410.0	1,887.0	2,172.0	1,969.0	1,933.0	2,089.0	2,795.0	2,682.0	9,983.0
Accrued Exp.	3,862.0	5,176.0	4,530.0	4,890.0	6,639.0	6,488.0	6,376.0	7,305.0	6,793.0	5,943.0	5,964.0	0.0
Short-term Borrowings	3,235.0	5,919.0	6,066.0	6,749.0	8,100.0	12,871.0	16,297.0	16,901.0	19,130.0	13,129.0	12,498.0	13,398.0
Current Portion of Long Term Debt	33.0	133.0	465.0	51.0	1,276.0	2,041.0	1,577.0	1,024.0	3,552.0	2,729.0	3,571.0	3,264.0
Curr. Income Taxes Payable	567.0	258.0	252.0	264.0	273.0	362.0	471.0	309.0	400.0	331.0	307.0	355.0
Def. Tax Liability, Curr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	743.0	692.0	0.0
Other Current Liabilities	264.0	359.0	305.0	357.0	333.0	349.0	1,131.0	339.0	410.0	1,259.0	818.0	633.0
Total Current Liabilities	**8,890.0**	**13,225.0**	**12,988.0**	**13,721.0**	**18,508.0**	**24,283.0**	**27,821.0**	**27,811.0**	**32,374.0**	**26,929.0**	**26,532.0**	**27,633.0**
Long-Term Debt	1,314.0	3,277.0	2,781.0	5,059.0	14,138.0	13,656.0	14,742.0	19,157.0	19,100.0	28,543.0	29,732.0	32,505.0
Pension & Other Post-Retire. Benefits	1,246.0	830.0	1,581.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Def. Tax Liability, Non-Curr.	608.0	1,890.0	877.0	1,580.0	4,261.0	4,694.0	4,981.0	6,152.0	5,636.0	4,691.0	3,753.0	4,313.0
Other Non-Current Liabilities	985.0	2,303.0	1,430.0	2,965.0	4,697.0	5,420.0	5,462.0	3,495.0	4,352.0	4,069.0	4,033.0	3,912.0
Total Liabilities	**13,043.0**	**21,525.0**	**19,657.0**	**23,325.0**	**41,604.0**	**48,053.0**	**53,006.0**	**56,615.0**	**61,462.0**	**64,232.0**	**64,050.0**	**68,363.0**
EQUITY												
Common Stock	878.0	880.0	880.0	880.0	880.0	1,760.0	1,760.0	1,760.0	1,760.0	1,760.0	1,760.0	1,760.0
Additional Paid In Capital	5,983.0	7,378.0	7,966.0	8,537.0	10,057.0	10,332.0	11,379.0	12,276.0	13,154.0	14,016.0	14,993.0	15,699.0
Retained Earnings	33,468.0	36,235.0	38,513.0	41,537.0	49,278.0	53,621.0	58,045.0	61,660.0	63,408.0	65,018.0	65,502.0	64,759.0
Treasury Stock	(22,118.0)	(23,375.0)	(24,213.0)	(25,398.0)	(27,762.0)	(31,304.0)	(35,009.0)	(39,091.0)	(42,225.0)	(45,066.0)	(47,988.0)	(50,256.0)
Comprehensive Inc. and Other	(1,291.0)	626.0	(2,674.0)	(757.0)	(1,450.0)	(2,774.0)	(3,385.0)	(3,432.0)	(5,777.0)	(10,174.0)	(11,205.0)	(9,843.0)
Total Common Equity	**16,920.0**	**21,744.0**	**20,472.0**	**24,799.0**	**31,003.0**	**31,635.0**	**32,790.0**	**33,173.0**	**30,320.0**	**25,554.0**	**23,062.0**	**22,119.0**
Minority Interest	0.0	0.0	390.0	547.0	314.0	286.0	378.0	267.0	241.0	210.0	158.0	33.0
Total Equity	**16,920.0**	**21,744.0**	**20,862.0**	**25,346.0**	**31,317.0**	**31,921.0**	**33,168.0**	**33,440.0**	**30,561.0**	**25,764.0**	**23,220.0**	**22,152.0**
Total Liabilities And Equity	**29,963.0**	**43,269.0**	**40,519.0**	**48,671.0**	**72,921.0**	**79,974.0**	**86,174.0**	**90,055.0**	**92,023.0**	**89,996.0**	**87,270.0**	**90,515.0**

Appendix Table 4: Cash Flow Statement

THE COCA-COLA COMPANY (NYSE:KO)

CASH FLOW STATEMENT - USD IN MILLIONS												LTM
Period Date	**31/12/2006**	**31/12/2007**	**31/12/2008**	**31/12/2009**	**31/12/2010**	**31/12/2011**	**31/12/2012**	**31/12/2013**	**31/12/2014**	**31/12/2015**	**31/12/2016**	**29/09/2017**
Net Income	**5,080**	**5,981**	**5,807**	**6,824**	**11,787**	**8,584**	**9,019**	**8,584**	**7,098**	**7,351**	**6,527**	**4,550**
Depreciation & Amort.	784	979	1,012	1,023	1,204	1,672	1,723	1,743	1,736	1,753	1,603	1,206
Amort. of Goodwill and Intangibles	154	184	216	213	239	282	259	234	240	217	184	184
Depreciation & Amort., Total	**938**	**1,163**	**1,228**	**1,236**	**1,443**	**1,954**	**1,982**	**1,977**	**1,976**	**1,970**	**1,787**	**1,390**
(Gain) Loss From Sale Of Asset	(303)	(244)	(130)	(43)	(5,358)	(220)	(98)	(670)	831	(374)	1,146	1,724
(Income) Loss on Equity Invest.	124	(452)	1,128	(359)	(671)	(269)	(426)	(201)	(371)	(122)	(449)	(591)
Stock-Based Compensation	324	313	266	241	380	354	259	227	209	236	258	234
Other Operating Activities	409	429	27	851	1,581	964	989	1,557	1,311	1,624	(252)	1,392
Change in Acc. Receivable	(214)	(406)	148	(404)	(41)	(562)	(33)	28	(253)	(212)	(28)	(28)
Change In Inventories	(150)	(258)	(165)	(50)	182	(447)	(286)	(105)	35	(250)	(142)	(142)
Change in Acc. Payable	173	762	(576)	319	656	63	(556)	(158)	(250)	1,004	(540)	(540)
Change in Inc. Taxes	(68)	185	(121)	81	(266)	(132)	770	22	151	(306)	750	750
Change In Other Net Operating Assets	(356)	(323)	(41)	(510)	(161)	(815)	(975)	(719)	(122)	(393)	(261)	(748)
Cash from Ops.	**5,957**	**7,150**	**7,571**	**8,186**	**9,532**	**9,474**	**10,645**	**10,542**	**10,615**	**10,528**	**8,796**	**7,991**
Capital Expenditure	(1,407)	(1,648)	(1,968)	(1,993)	(2,215)	(2,920)	(2,780)	(2,550)	(2,406)	(2,553)	(2,262)	(1,895)
Sale of Property, Plant, and Equipment	112	239	129	104	134	101	143	111	223	85	150	130
Cash Acquisitions	0	0	(534)	(300)	(2,511)	(971)	(666)	(353)	0	(2,491)	(838)	(609)
Divestitures	640	448	479	0	972	4	20	872	148	565	1,035	3,080
Sale/(Purchase) of Intangible Assets	(901)	(5,653)	(225)	0	0	0	0	0	0	0	0	0
Invest. in Marketable & Equity Sec.	(82)	(99)	(240)	(1,912)	(679)	1,407	(7,853)	(1,991)	(5,203)	(1,752)	1,125	(116)
Other Investing Activities	(62)	(6)	(4)	(48)	(106)	(145)	(268)	(303)	(268)	(40)	(209)	(12)
Cash from Investing	**(1,700)**	**(6,719)**	**(2,363)**	**(4,149)**	**(4,405)**	**(2,524)**	**(11,404)**	**(4,214)**	**(7,506)**	**(6,186)**	**(999)**	**578**
Short Term Debt Issued	0	0	0	0	0	0	0	0	0	0	0	0
Long-Term Debt Issued	617	9,979	4,337	14,689	15,251	27,495	42,791	43,425	41,674	40,434	27,281	0
Total Debt Issued	**617**	**9,979**	**4,337**	**14,689**	**15,251**	**27,495**	**42,791**	**43,425**	**41,674**	**40,434**	**27,281**	**29,513**
Short Term Debt Repaid	0	0	0	0	0	0	0	0	0	0	0	0
Long-Term Debt Repaid	(2,021)	(5,638)	(4,308)	(12,326)	(13,403)	(22,530)	(38,573)	(38,714)	(36,962)	(37,738)	(25,615)	0
Total Debt Repaid	**(2,021)**	**(5,638)**	**(4,308)**	**(12,326)**	**(13,403)**	**(22,530)**	**(38,573)**	**(38,714)**	**(36,962)**	**(37,738)**	**(25,615)**	**(27,633)**
Issuance of Common Stock	148	1,619	595	664	1,666	1,569	1,489	1,328	1,532	1,245	1,434	1,459
Repurchase of Common	(2,416)	(1,838)	(1,079)	(1,518)	(2,961)	(4,513)	(4,559)	(4,832)	(4,162)	(3,564)	(3,681)	(4,259)
Common Dividends Paid	(2,911)	(3,149)	(3,521)	(3,800)	(4,068)	(4,300)	(4,595)	(4,969)	(5,350)	(5,741)	(6,043)	(6,180)
Total Dividends Paid	**(2,911)**	**(3,149)**	**(3,521)**	**(3,800)**	**(4,068)**	**(4,300)**	**(4,595)**	**(4,969)**	**(5,350)**	**(5,741)**	**(6,043)**	**(6,180)**
Other Financing Activities	0	0	(9)	(2)	50	45	100	17	(363)	251	79	(161)
Cash from Financing	**(6,583)**	**973**	**(3,985)**	**(2,293)**	**(3,465)**	**(2,234)**	**(3,347)**	**(3,745)**	**(3,631)**	**(5,113)**	**(6,545)**	**(7,261)**
Foreign Exchange Rate Adj.	65	249	(615)	576	(166)	(430)	(255)	(611)	(934)	(878)	(6)	73
Misc. Cash Flow Adj.	0	0	0	0	0	0	0	0	0	0	0	0
Net Change in Cash	**(2,261)**	**1,653**	**608**	**2,320**	**1,496**	**4,286**	**(4,361)**	**1,972**	**(1,456)**	**(1,649)**	**1,246**	**1,381**

Appendix B – DCF Calculations

Appendix Table 5: Historical Unlevered FCF

PROJECTED CASH FLOWS

(USD in millions, except per share data)

Fiscal Year Ending December	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	LTM
Total Revenue	24,088	28,857	31,944	30,990	35,119	46,542	48,017	46,854	45,998	44,294	41,863	37,307
Annual Growth	*NA*	*19.8%*	*10.7%*	*(3.0%)*	*13.3%*	*32.5%*	*3.2%*	*(2.4%)*	*(1.8%)*	*(3.7%)*	*(5.5%)*	*(3.4%)*
Cost of Revenue	8,160	10,406	11,374	11,088	12,693	18,204	19,053	18,421	17,889	17,482	16,465	14,361
Margin	*33.9%*	*36.1%*	*35.6%*	*35.8%*	*36.1%*	*39.1%*	*39.7%*	*39.3%*	*38.9%*	*39.5%*	*39.3%*	*39.3%*
EBITDA	7,435	8,415	10,024	9,780	10,408	12,866	13,198	13,082	12,843	12,210	11,531	10,946
Annual Growth	*NA*	*13.2%*	*19.1%*	*(2.4%)*	*6.4%*	*23.6%*	*2.6%*	*(0.9%)*	*(1.8%)*	*(4.9%)*	*(5.6%)*	*(5.1%)*
Margin	*30.9%*	*29.2%*	*31.4%*	*31.6%*	*29.6%*	*27.6%*	*27.5%*	*27.9%*	*27.9%*	*27.6%*	*27.5%*	*27.5%*
Less: Depreciation and Amortization	938	1,163	1,228	1,236	1,443	1,954	1,982	1,977	1,976	1,970	1,787	1,390
% of Capital Expenditure	*66.7%*	*70.6%*	*62.4%*	*62.0%*	*65.1%*	*66.9%*	*71.3%*	*77.5%*	*82.1%*	*77.2%*	*79.0%*	*79.0%*
EBIT	6,497	7,252	8,796	8,544	8,965	10,912	11,216	11,105	10,867	10,240	9,744	9,556
Annual Grov Annual Growth	*NA*	*11.6%*	*21.3%*	*(2.9%)*	*4.9%*	*21.7%*	*2.8%*	*(1.0%)*	*(2.1%)*	*(5.8%)*	*(4.8%)*	*(1.9%)*
Margin	*27.0%*	*25.1%*	*27.5%*	*27.6%*	*25.5%*	*23.4%*	*23.4%*	*23.7%*	*23.6%*	*23.1%*	*23.3%*	*25.6%*
Less: Income Taxes	(1,364)	(1,523)	(1,847)	(1,794)	(1,883)	(2,292)	(2,355)	(2,332)	(2,282)	(2,150)	(2,046)	(2,007)
Unlevered Net Income	5,133	5,729	6,949	6,750	7,082	8,620	8,861	8,773	8,585	8,090	7,698	7,549
Plus: Depreciation and Amortization	938	1,163	1,228	1,236	1,443	1,954	1,982	1,977	1,976	1,970	1,787	1,390
Less: Capital Expenditure	(1,407)	(1,648)	(1,968)	(1,993)	(2,215)	(2,920)	(2,780)	(2,550)	(2,406)	(2,553)	(2,262)	(1,895)
Margin	*(5.8%)*	*(5.7%)*	*(6.2%)*	*(6.4%)*	*(6.3%)*	*(6.3%)*	*(5.8%)*	*(5.4%)*	*(5.2%)*	*(5.8%)*	*(5.4%)*	*(5.5%)*
Less: Additions to Intangibles	(901)	(5,653)	(225)	0	0	0	0	0	0	0	0	0
Less: Increase in Working Capital	(615)	(40)	(755)	(564)	370	(1,893)	(1,080)	(932)	(439)	(157)	(221)	(708)
Margin	*(2.6%)*	*(0.1%)*	*(2.4%)*	*(1.8%)*	*1.1%*	*(4.1%)*	*(2.2%)*	*(2.0%)*	*(1.0%)*	*(0.4%)*	*(0.5%)*	*(1.2%)*
Reinvestment Rate	*38.7%*	*107.8%*	*24.8%*	*19.6%*	*5.7%*	*33.2%*	*21.2%*	*17.2%*	*10.1%*	*9.1%*	*9.0%*	*16.1%*
Unlevered Free Cash Flow	3,148	(449)	5,229	5,429	6,680	5,761	6,983	7,268	7,716	7,350	7,002	6,336
Annual Growth	*NA*	*(114.3%)*	*(1264.8%)*	*3.8%*	*23.1%*	*(13.8%)*	*21.2%*	*4.1%*	*6.2%*	*(4.7%)*	*(4.7%)*	*(9.5%)*
Discount Factor - End-of-Period Convention										0.95	1.95	2.95
PV of Yearly Cash Flows										5,722.8	0.1	0.0

Appendix Table 6: WACC Calculation

WACC	
Market Risk Premium (Rm - Rf)	5.1%
Multiplied by: NYSE:KO Bottom-Up Beta	0.557
Adjusted Market Risk Premium	2.9%
Add: Risk-Free Rate of Return (Rf)(1)	2.9%
Add: Size Premium	0.0%
Cost of Equity	**5.8%**
Multiplied by: NYSE:KO E/(D+P+E)	80.2%
Cost of Equity Portion	4.6%
NYSE:KO Cost of Debt (Rd) - Average of Last 5 Issued Bonds	3.1%
Multiplied by: NYSE:KO D/(D+P+E)	19.8%
Cost of Debt Portion	0.6%
NYSE:KO Cost of Preferred (Rp)	**0.0%**
Multiplied by: NYSE:KO P/(D+P+E)	0.0%
Cost of Preferred Portion	0.0%
WACC	**5.2%**
WACC Distribution Definition	**5.2%**

Appendix Table 7: Beta Estimation

BETA CALCULATION								
Ticker	**Name**	**Levered Beta**	**Total Debt**	**Mkt. Val. Equity**	**Pref Equity**	**Debt/ Equity**	**Pref/ Equity**	**Unlevered Beta(2)**
NasdaqGS:PEP	Pepsico, Inc.	0.701	39,169.0	169,306.2	(155.0)	23.1%	-0.1%	0.593
NasdaqGS:MNST	Monster Beverage Corporatior	0.941	0.0	37,486.6	0.0	0.0%	0.0%	0.941
NYSE:DPS	Dr Pepper Snapple Group, Inc	0.605	4,486.0	17,209.2	0.0	26.1%	0.0%	0.502
NYSE:STZ	Constellation Brands, Inc.	0.077	9,350.2	42,369.1	0.0	22.1%	0.0%	0.065
ENXTAM:CCE	Coca-Cola European Partners	0.000	7,243.6	18,979.9	0.0	38.2%	0.0%	0.000
TSX:BCB	Cott Corporation	0.351	1,536.6	2,337.0	0.0	65.7%	0.0%	0.231
Average		**0.535**						**0.466**
Average Unlevered Beta for Comps								0.466
NYSE:KO D/E								24.6%
Tax Rate (5 Year Average)								21.0%
NYSE:KO Levered Beta -3								**0.557**

Appendix C – Valuation Methods Applications Results

Appendix Table 8: WACC - Earnings Power Valuation

WACC - Earnings Power Valuation		
Enterprise Value		144,051
Less:		
	Total Debt	(49,167.0)
	Preferred Stock	0.0
	Minority Interest	(33.0)
Plus:		
	Cash and Equivalents	27,357.0
Equity Value		122,207.9
Shares Outstanding		4,260.7
Implied Per Share Value		28.68
Current Price		46.88
Value of Financing Effects		2.42
Investment Value		-15.77
Premium/(Discount) to Current Price		*(38.8%)*

Appendix Table 9: WACC - EP Growth Valuation

WACC - Earnings Power Growth Valuation		
Growth		1.5%
Enterprise Value		205,487
Less:		
	Total Debt	(49,167.0)
	Preferred Stock	0.0
	Minority Interest	(33.0)
Plus:		
	Cash and Equivalents	27,357.0
Equity Value		183,643.6
Plus:		
	Value of Financing Effects	10,325
Total Value		**193,969**
Shares Outstanding		4,260.7
Implied Per Share Value		43.10
Cv MOS		31%
Yee's Option Model MOS		41%
Current Price		46.88
Investment Value_No MOS		-3.78
Investment Value_Cv MOS		-16.98
Investment Value_Yee MOS		-21.35

Appendix Table 10: No Adjustments Valuation

No Adjustments - Earnings Power Growth Valuation		
Growth		1.5%
Enterprise Value		548,408
Less:		
	Total Debt	(49,167.0)
	Preferred Stock	0.0
	Minority Interest	(33.0)
Plus:		
	Cash and Equivalents	27,357.0
Equity Value		526,565.3
Plus:		
	Value of Financing Effects	10,325
Total Value		**536,890**
Shares Outstanding		4,260.7
Implied Per Share Value		123.59
Cv MOS		67%
Yee's Option Model MOS		54%
Current Price		46.88
Investment Value_No MOS		76.71
Investment Value_Cv MOS		-5.93
Investment Value_Yee MOS		10.44

Appendix Table 11: ZZ Certainty Equivalent Valuation

ZZ-Certainty Equivalent		
Growth		1.5%
FCF Distr. Def.		6,887
Implied FCF Volatility		9%
Enterprise Value		369,751
Less:		
	Total Debt	(49,167.0)
	Preferred Stock	0.0
	Minority Interest	(33.0)
Plus:		
	Cash and Equivalents	27,357.0
Equity Value		347,908.4
Plus:		
	Value of Financing Effects	10,325
Total Value		**358,233**
Shares Outstanding		4,260.7
Implied Per Share Value		81.66
Cv MOS		44%
Yee's Option Model MOS		46%
Current Price		46.88
Investment Value_No MOS		34.78
Investment Value_Cv MOS		-1.50
Investment Value_Yee MOS		-3.12

Appendix Table 12: Haircut Method Valuation

Haircut Method		
Growth Distribution Def.		1.0%
Adj. Earnings Distribution Def.		4,682
Enterprise Value		250,664
Less:		
	Total Debt	(49,167.0)
	Preferred Stock	0.0
	Minority Interest	(33.0)
Plus:		
	Cash and Equivalents	27,357.0
Equity Value		228,821.1
Plus:		
	Value of Financing Effects	10,325
Total Value		**239,146**
Shares Outstanding		4,260.7
Implied Per Share Value		53.71
Cv MOS		27%
Yee's Option Model MOS		39%
Current Price		46.88
Investment Value_No MOS		6.83
Investment Value_Cv MOS		-7.42
Investment Value_Yee MOS		-14.03

Appendix Table 13: Wang Transform Valuation

Wang Transformation (CAPM)		
Growth		1.5%
Enterprise Value		548,408
Less:		
	Total Debt	(49,167.0)
	Preferred Stock	0.0
	Minority Interest	(33.0)
Plus:		
	Cash and Equivalents	27,357.0
Equity Value		526,565.3
Plus:		
	Value of Financing Effects	10,325
Total Value		**536,890**
Shares Outstanding		4,260.7
Implied Per Share Value		123.59
Cv MOS		67%
Yee's Option Model MOS		54%
Current Price		46.88
Investment Value_No MOS		76.71
Investment Value_Cv MOS		-5.93
Investment Value_Yee MOS		10.44

Dealing with Uncertainty in Value Investing

Introduction

Value investing is an investment strategy in which an investor invests in securities that trade at a significant discount to their intrinsic value. It was first pioneered by Benjamin Graham and David Dodd during the 1930's (Graham and Dodd, 1934; Graham, 1949) and has since found a lot of supporters around the globe, including some of the most successful investors that ever existed (Buffett, 1984). According to Athanasakos (2012), there are three fundamental steps in every value-oriented investment process:

[1] Identify possibly undervalued securities through a screening process
[2] Calculation of the intrinsic value
[3] Comparison of the intrinsic value with the current market price, and, if a significant discount exists, which is known as "Margin of Safety", then the investment is undertaken

By examining this process, we identify that there is a lot of inherent uncertainty in the second and third steps. Although a lot of literature has been written on this subject (for example, Graham and Dodd, 1934; Graham, 1949; Klarman, 1991; Athanasakos, 2012; Damodaran 2010, 2011, 2012) we have found that most them are either qualitative in nature or fail to address simultaneously the uncertainty of both steps in a quantitative manner. Thus, the purpose of this dissertation is to create a unifying quantitative framework under which a value investor can model and measure the uncertainty inherent in the investment process. Obviously, given the time and resource constraints of this project, only a small part of the available tools will be examined and reported. More details about the two steps and the modelling of uncertainty are presented below:

Step 2 – Intrinsic Value

How can an investor estimate with precision the intrinsic value of a security? The answer is simple: they can't. The three approaches to valuation according to Damodaran (2010, 2011, 2012) are:

[1] Intrinsic valuation, which relates the value of an asset to its intrinsic characteristics, i.e. its capacity to generate cash flows and the risk of those cash flows. It is usually done through a discounted cash flow method.
[2] Relative valuation, where the value of an asset is estimated by looking at the pricing of comparable assets
[3] Contingent claim valuation, where option pricing models are used to measure the value of an asset that has option characteristics.

For the purposes of this dissertation, we will focus only on intrinsic valuation and the probabilistic extension of the well-known deterministic DCF analysis. By treating the inputs of the DCF analysis as random variables rather than point estimates, investors can estimate intrinsic value as a random variable and, thus, model uncertainty. We will make a review of both the existing closed form methods (for example, Hillier, 1963, 1969; Wagle, 1967; Kim et al., 1999; Tung, 1992) and the numerical techniques that exist (for example, Hertz, 1964; Mercer and Morgan, 1975; Canada and White, 1980; Mosca et al., 2001). Other, simpler tools like sensitivity analysis, decision trees, scenario analysis, risk-adjusted discount rates and break-even analysis will not be examined as they are already covered extensively in literature (for example, Damodaran, 2012). Moreover, since value investors care a lot more about risk defined as the probability of losing money –instead of the classical view of risk defined as volatility of returns via Modern Portfolio Theory (Klarman, 1991, 2009; Athanassakos, 2012)– we will use stochastic ordering to deal with competing investments from which an investor may have to choose due to capital constraints (Barnes et al, 1978).

Step 3 – Margin of Safety

What is an adequate margin of safety and how is it calculated? Although this concept is very popular among value investors, academic research is surprisingly scant on this concept, with only Yee (2008) developing a model based on real-options in an attempt to estimate what is a sufficient Margin of Safety (MoS). According to Yee, the fundamental risks that an investor faces, and, thus, the ones the MoS depends on are:

- *market risk:* volatility of the market price;
- *news risk:* risk that intervening news between t* and T disrupts the investor's projected fundamental value estimate;
- *valuation risk:* fear that her estimate of V_t may be systematically biased or imprecise;
- *convergence risk:* uncertainty about date T, when the market price will converge to the projected valuation estimate

To further extend this approach to MoS, we will link valuation risk with Step 2 of the process while also giving guidance for ways to estimate inputs for the other fundamental risks. Moreover, we will also use a probabilistic approach to model the uncertainty regarding the Margin of Safety –in contrast to the deterministic approach that Yee uses in his paper in order to illustrate how the model works.

Case Study

To complement the theoretical approach described above with a practical example, we will conduct a case study for a listed company where the three-step process described above will be undertaken. After selecting the company (which will be done later), we will start with a base case valuation of the firm. Then, we will use one of the tools described in step 2 to model uncertainty in our valuation process. Last, we will use a simulation to calculate a MoS for this investment. The data for this case study will be acquired by the appropriate sources (databases, company's website, etc.) as needed.

References

Athanassakos, G. (2012) Value Investing Vs. Modern Portfolio Theory, Journal of Business & Financial Affairs, [Online], 1:e110. Available: http://www.omicsgroup.org/journals/value-investing-vs-modern-portfolio-theory-2167-0234.1000e110.php?aid=5557

Barnes, J. W., Zinn, C. D. and Eldred, B. S. (1978) A methodology for obtaining the probability density function of the present worth of probabilistic cash flow profiles. AIIE Transactions, 10(3): pp. 226–236.

Buffett, W., (1984) The Superinvestors of Graham-and-Doddsville, Hermes, the Columbia Business School Magazine, [Online]. Available:
https://www8.gsb.columbia.edu/rtfiles/cbs/hermes/Buffett1984.pdf

Canada, J. R., and White, J. A. (1980) Capital investment decision analysis for management and engineering, Englewood Cliffs, NJ: Prentice-Hall.

Damodaran, A. (2010) Dark Side of Valuation, The: Valuing Young, Distressed, and Complex Businesses, 2nd Edition, Financial Times Prentice Hall.

Damodaran, A. (2011) The Little Book of Valuation: How to Value a Company, Pick a Stock and Profit, John Wiley and Sons.

Damodaran, A. (2012) Investment Valuation: Tools and Techniques for Determining the Value of Any Asset, 3rd Edition, John Wiley and Sons.

Graham, B., and Dodd, D. (1934) Security Analysis, Whittlesey House, New York: McGraw-Hill Book Co.

Graham, B. (1949) The Intelligent Investor: A Book of Practical Counsel, New York: Harper & Row.

Hertz, D. B. (1964) Risk analysis in capital investment. Harvard Business Review, 42(1): pp. 95–106.

Hillier, F. S. (1963) The derivation of probabilistic information for the evaluation of risky investments. Management Science, 9(3), pp. 443–457.

Hillier, F. S. (1969) The evaluation of risky interrelated investments, Amsterdam: North-Holland.

Kim, S. H., Hussein, H. E., and Kim, D. J. (1999) Derivation of an intertemporal correlation coefficient model based on cash flow components and probabilistic evaluation of a project's NPV. *The Engineering Economist*, 44(3), pp. 276–294.

Klarman, S. (1991) Margin of Safety: Risk-Averse Value Investing Strategies for the Thoughtful Investor, New York: HarperCollins.

Klarman, S. (2009) Presentation at the Ben Graham Centre for Value Investing, Richard Ivey School of Business, [Online]. Available:
https://www.ivey.uwo.ca/bengrahaminvesting/news/2009/03/seth-klarman-speaks-to-ivey-value-investing-class/

Mercer, L. J., and Morgan, W. D. (1975) Evaluation of a probability approach to uncertainty in benefit-cost analysis, Davis: California Water Resources Center, University of California, Report No. 149.

Tung, Y. K. (1992) Probability distribution for benefit/cost ratio and net benefit. Journal of Water Resources Planning and Management, 118(2), pp.133–150.

Wagle, B. 1967. A statistical analysis of risk in capital investment projects. Operational Research Society, 18(1), pp. 13–33.

Yee, K. (2008), Deep-Value Investing, Fundamental Risks, and the Margin of Safety. The Journal of Investing 2008.17.3, pp. 35-46.